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# ENGINEERING:

## An Illustrated Weekly Journal.

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19th August, 1921. R 834

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The Commissioners do not bind themselves to accept the lowest or any Tender.
By Order,
J. McD. MANSON,
General Manager and Secretary.
Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
30th August, 1921. R 838

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A. MUIRHEAD,
Managing Director.
91, Petty France, S.W. 1.
30th August, 1921. R 943

COUNTY BOROUGH OF WALSALL.

ELECTRIC SUPPLY DEPARTMENT.

TENDER FOR CAST IRON PIPES.

The Electric Supply Committee of the Walsall Town Council invite

## Tenders for the Supplying

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Copies of the drawings and specifications may also be seen at the offices of Mr. H. A. HOWIE, Engineer and Manager Electric Supply Department, Wolverhampton Street, Walsall.
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Council House,
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September, 1921. R 950

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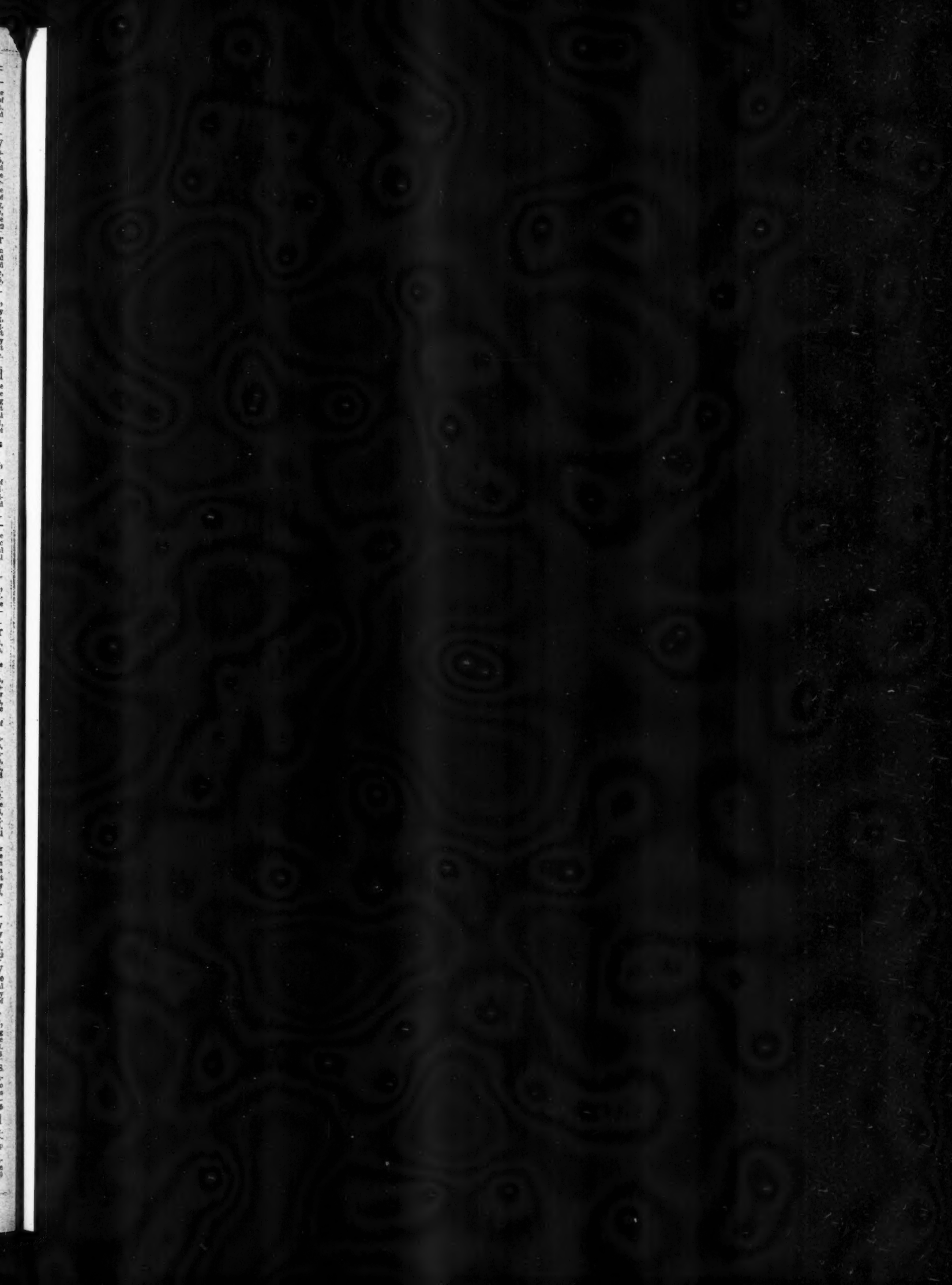


## DIRECTION-FINDING WIRELESS.

By J. J. BENNETT.

DIRECTION-FINDING wireless, which came into use for naval purposes during the war, is now being applied to the service of the mercantile marine. The system has been adopted by France, America and Canada, each of which has a number of stations in operation. So far as the United Kingdom is concerned, the Admiralty intend to maintain their direction-finding stations at the Lizard and at Carnsore Point. The stations at Flamborough and Berwick will also be retained until the end of the year. After that their continuance is uncertain, unless some other authority takes them over. As a fee of only 5*s.* is charged for giving a ship a bearing from one of these stations and the great value of them as an adjunct to navigation has been proved on many occasions, it would be regrettable if any of those established on our coasts had to be dismantled because nobody would undertake their upkeep. At the moment it seems probable that this is what will happen.

The principal use of direction-finding wireless as an aid to navigation is in enabling the bearing of a vessel in open waters, or when approaching pilotage waters, to be determined from one or more fixed points. When the bearings from two or more fixed points are obtained simultaneously the position of the vessel can be located by the intersection of the bearings. All bearings thus obtained by wireless telegraphy are the Great Circle bearings at the place where the bearings are observed. This means that in some cases, which will be explained later, the vessel will require special charts or special tables of correction. Independent of technical systems, there are three types of direction-finding wireless which may be employed as an aid to the navigation of ships. These are: (1) The direction-finding station type, in which a vessel transmits by her ordinary wireless installation to a fixed station, or stations, on shore that are fitted with directional wireless apparatus. The shore station determines the bearing and transmits it to a ship in the ordinary manner. Two or more stations may be grouped to determine simultaneously the bearing of the vessel from each station, and the intersection of the respective bearings, as transmitted by ordinary wireless telegraphy to the vessel by the master station of the shore group, enables the position of the vessel to be ascertained. In this case the responsibility for the accuracy rests with the station, and the vessel herself requires no special direction-finding apparatus.

(2) The beacon station type: In this the vessel is fitted with direction-finding apparatus by means of which the relative bearing of one or more ordinary fixed transmitting stations can be determined and the vessel's position located by the intersection of the bearings. These are necessarily obtained relatively to the ship's course at the time and are corrected accordingly. Any known ordinary wireless telegraphy station may be used for this purpose, or, preferably, certain stations known as beacon stations may be directed to transmit simultaneously, or successively, pre-arranged signals on certain wave-lengths at definite times during each hour. Under this system the responsibility for the accuracy of the bearing rests with the vessel, which must have a special direction-finding apparatus on board.

(3) The directional transmitting station type: In this method a rotating directional wireless beam having a fixed angular velocity is transmitted by a specially-fitted fixed transmitting station. The rotating beam, which swings round in similar fashion to the revolving beam of a lighthouse, has a sharply-defined zero position which passes through north and south at given times. Knowing the angular velocity of the beam, and by observing the time interval between the given times at which the zero passes through north and south and the time at which the zero signals are received in the ship, the bearing of the station can be determined. In order to ensure that the watches in the transmitting station and the receiving ships are synchronised the station transmits a timing signal first before commencing the rotating beam. In order to avoid calculation in the ship, and to obtain greater accuracy, a special watch, the face of which is marked in degrees, is required in the ship, and the scale corresponding to the angular velocity of the revolving beam. If this watch is started at the moment indicated by the timing signal the bearing in degrees of the ship from the station can be noted from the watch at the moment when the zero signals are received. This bearing can be checked with subsequent zeroes. In this method the responsibility for the accuracy of the bearing rests with the ship.

The principles of direction-finding wireless and the technical methods of operating it may be epitomised as follows: Signals from an ordinary wireless transmitting aerial are propagated equally in all directions in a horizontal plane. The field of magnetic lines surrounding the aerial may be regarded as a series of concentric rings spreading outward uniformly from the transmitter; and the receptive powers of an ordinary vertical earthed aerial, apart from local or special conditions which may cause screening, may be regarded as equal in all directions. We will suppose that a receiving ship or station is fitted with a single loop aerial, *i.e.*, a triangle as shown in Fig. 1, and that this aerial is not earthed, but that the two ends are connected to an ordinary receiving circuit so as to form a closed loop. A and B represent the two sides of this single loop and the arrows the direction of advancing wireless waves. If the plane of this loop be parallel to the direction of the advancing waves, the direction of the current set up in A will be in the same direction as that set up in B, so that the currents will tend to oppose each other. But if the two sides of the loop are spaced a certain distance apart the current induced in one side will reach its maximum an instant later than that in the other side and a resultant current will flow round the loop. If the loop now be turned through an angle of 90 deg. so that its plane is at right angles to the direction of the advancing waves which are shown as facing or end-on arrows in Fig. 2, then it is clear that the electromotive force induced in the two sides will at any instant be equal and will oppose each other, so that no current will flow round the loop.

*Fig. 1. MAXIMUM CURRENT IN LOOP.*

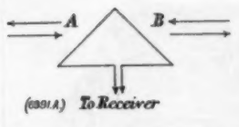



*Fig. 2. ZERO CURRENT IN LOOP.*

*Fig. 3. FIELD OF MAGNETIC LINES OF FORCE THROUGH A LOOP AERIAL.*

If the loop be turned through any other angle than a right angle then a resultant current will flow round the loop having a value which varies as the cosine of the angle which the plane of the loop makes with the direction of the advancing wave. Or, in other words, the loop aerial may be regarded as normally inductive to the field of magnetic force of the advancing waves, but as non-inductive to that field in certain positions. This is shown in Fig. 3, where for the sake of simplicity in drawing it is assumed that instead of being rotated the loop is moved round the transmitting station so that its plane is pointing at the transmitting station at the right hand, or maximum current position, and is facing the transmitter at the lower, or zero, current position.

Therefore, it follows that by means of a revolving loop aerial the direction of a distant station may be determined by the relative strength of the signals in different positions, and the single-loop aerial connected to receiving instruments and rotated round its vertical axis through a horizontal scale is the simplest form of direction-finding apparatus.

To increase the current through the loop it is usual to tune the loop with a condenser to the wave-lengths required to be received, and instead of a single loop a frame fitted with a multi-turn loop may be used. The larger the area of the loop the greater will be the resultant current induced. The revolving loop aerial system of direction finding has the advantage of simplicity and portability, but it does not lend itself so readily to the accurate reading of directions, especially when the loop is large and in consequence cumbersome. This system is not very suitable for work on board ship because the revolving loop requires to be set up in such a position that it is not influenced unequally during its orientation by other conductors in the vicinity. Here it should be noted that the zero position of signal strength, *i.e.*, when the loop is at right angles to the direction of the advancing wave, is much more sharply defined than the maximum position of signal strength, and it is usual in practice to read the zero position, which is 90 deg. away from the true bearing. This can be done most conveniently by judging two positions on the scale at which the signals are of equal strength on either side of the zero point, the mean of the two scale readings giving the exact zero. Improvements are now being introduced by which a comparison method is substituted for the zero method of determining the bearing. These involve an addition to the simple apparatus here described. It should be noted that the system of directional wireless explained above gives only the direction and not the sense of the incoming signal, so that there is an ambiguity of 180 deg. In the majority of cases, since either the receiver or transmitter is in a fixed position, the ambiguity is of little consequence.

In the Bellini-Tosi system, in place of a rotary loop aerial two fixed loop aerials are employed which are connected to an instrument known as the radiogoniometer, or direction range-finding transformer. Inside the latter instrument is a small receiving coil attached to a pointer moving over a scale by which the direction of signals can be determined.

Let us take the case of a receiving set having two fixed loop aerials at right angles to each other. When the direction of the transmitting station is in the plane of one of the aerials maximum signals will be received on this aerial and zero signals on the other. Thus, if the signals are from a distant station at X or X 1 (Fig. 4), maximum signals will be received in coil A B and zero in coil C D. If the signals are from Y to Y 1, maximum signals will be received in coil C D and zero in coil A B. When the direction of the transmitting station is not in one of these two planes, *e.g.*, at Z in Fig. 4, the signals will be received to a certain extent on both aerials, that is, a current will be induced in both aerials, the magnitude in each of which will be proportional to the cosine of the respective angle which each makes with the direction of the transmitting station. The two aerials are joined respectively to two small loops, each loop being a coil of several turns, fixed at right angles to each other in the radiogoniometer, so that this instrument forms a small replica of the large fixed aerials and reproduces faithfully the magnetic fields due to the currents induced in the two aerials.

Fig. 5 shows in diagrammatic form the radiogoniometer joined to two fixed triangular aerials, and Fig. 6 shows the actual radiogoniometer or direction finding box. The two fields due to the separate currents in the two fixed aerials combine to form a resultant field. In order that this resultant field shall have the true direction of the transmitting station, that is, in order that the resultant field due to the currents in the coils A B and C D from a transmitting station at Z (Fig. 4) shall lie along the dotted line E F, it is necessary that the two aerials should each receive their proportionate share of current. The receptive powers of both aerials must, therefore, be similar, and if the position of the direction finder is isolated from all other conductors, *e.g.*, set up ashore in a suitable position, it is clear that this will be obtained by

making the two aerials identical in all respects. If the aerials are set up in a ship the influence of other conductors in the vicinity of one aerial may be considerably greater than that affecting the other. Consequently, in order to keep the receptive powers of the aerials equal it may be necessary to employ a smaller loop for one aerial than for the other.

Assuming that the resultant field in the two aerials gives the direction of the transmitting station, then by joining the two coils of the radiogoniometer to their respective aerials so that the current in each aerial passes through its radiogoniometer coil, the resultant field can be faithfully reproduced in a concentrated form in this instrument. The direction of this field, that is, the bearing of the station, is obtained by revolving a small coil, known as the search or exploring coil, to which a pointer travelling over a scale marked in degrees, from 0 deg. to 360 deg., is attached. Fig. 7 shows the scale and diagrammatic plan of a radiogoniometer. It is usual to determine the zero position of the signals in taking directions, and if the search coil pointer is adjusted at 90 deg. to the plane of the search

*Fig. 4.*

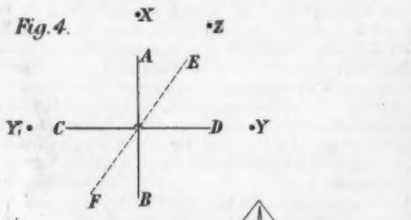
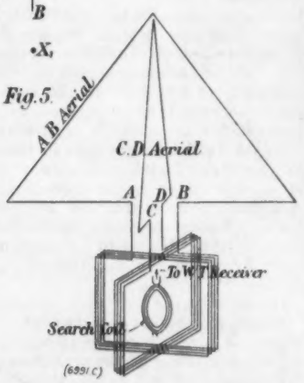



*Fig. 5.*




coil and if the aerials at the station are set up as shown in Fig. 7, the zero signal position as determined from the pointer will give the actual true bearing of the station or its reciprocal in degrees. If the direction-finding apparatus is set up in a ship with the plane of the aerial in the fore and aft and athwartship lines the pointer will give the bearing of the station relative to the ship's course at the instant of receiving the signal, and the relative bearing must be corrected accordingly to give the true bearing.

A means of ascertaining the course of the ship whilst taking the bearings must, therefore, be available. In order to obtain maximum sensitivity for work at long ranges the two loop circuits, each formed by one aerial and its corresponding radiogoniometer coil (Fig. 5) may be tuned separately, by a condenser in each circuit, to the wave-length of the transmitting station. It is essential that the tuning of both circuits should be exactly the same, as inaccuracy in tuning will result in inaccuracy of bearings. To carry out this tuning preparatory to taking directions the two aerials are excited equally by a small buzzer circuit and the tuning condensers accurately adjusted until the buzzer signals are a minimum in a position known as the buzzer zero approximately midway between the planes of the two radiogoniometer loop coils. The sharpness of this buzzer zero is an indication of the accuracy in equality of tuning, and the operation known as balancing the aerials is performed frequently by the operator when keeping watch on the directional apparatus, and affords a check on the reliability of his instruments. For moderate range working, and in general because the operation of balancing the aerials requires skill and, if inaccurately carried out, may be a source of error, it is a common practice, especially in ship's sets, to short circuit or dispense with the tuning condensers. In this case, once the aerials have been definitely fixed and the calibration of the direction finder (an operation similar to that of adjusting a new ship's compass) has been carried out, the only adjustments required prior to the determination of a bearing by the radiogoniometer are those appertaining to the wireless receiving circuits attached to the direction finder.

These may be confined to a single adjustment in order to simplify the use of the apparatus. Attached to the search coil of the direction-finding apparatus are the wireless receiving circuits, consisting of a tuned receiving circuit, detecting and amplifying circuits. This apparatus, although differing in design possibly from the ordinary wireless receiving apparatus, follows the usual principle of receivers employed for ordinary wireless telegraphy and does not therefore need describing. But since the receptive powers of a comparatively small loop aerial such as can be used in direction finding are very much inferior to those of the ordinary type of ship or station-earthed aerials, the supply of signal amplifying apparatus employing several vacuum valves is not only desirable but an essential feature of the direction-finding receiver.

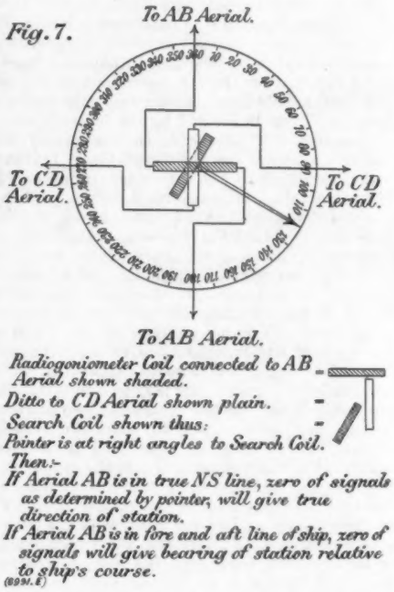
FIG. 6.

The foregoing explanation covers the principles and operational methods of the types of direction-finding wireless telegraphy known as the direction-finding station type and the Beacon station type. Up to the present these types, which comprise directional receiving aerials and apparatus either on shore or in a vessel, are the most commonly used. The procedure followed in communicating with a direction-finding type station is that the ship desirous of obtaining her bearing calls the shore station by her ordinary wireless telegraphy and asks for the bearing; the station indicates by wireless that it is ready to determine the bearing; the ship then transmits her call sign continuously for a short period, during which time the station ascertains the bearing by the use of its apparatus and transmits to the vessel by wireless her true bearing and the time at which the bearing was observed. If the ship requires simultaneous bearings from two directional shore stations so as to obtain her position, she calls up the controlling station of the group and intimates the fact. Both stations then determine simultaneously by their direction finders the respective bearings of the ship. The controlling station collects both bearings (a land line is used between the shore stations) and either transmits to the ship the two bearings and the time at which they were determined, or, if equipped for the purpose, determines the position as obtained from the two bearings and transmits it to the ship.

With a station of the "beacon" type a ship fitted with directional receiving apparatus can determine by the radiogoniometer of her apparatus, her bearing at any time convenient from a known ordinary wireless telegraphy station, or from a beacon station transmitting at routine times. The bearing as obtained is the angle between the course of the ship, *i.e.*, 360 deg. on the radiogoniometer or the fore and aft line of the ship, and the direction of the station, and this angle must be applied to the true course in order to obtain the true bearing of the station (see Fig. 8). A similar procedure may be adopted with two or more stations when it is desired to obtain a fix, the bearing of each station being observed in turn.

In the place of either of these two types using an ordinary transmitter and a directional receiver, there is, as already mentioned, a third type of station using the converse of these two principles. Instead of the ordinary transmitting station from which signals are sent in all directions, a special station is designed capable of transmitting signals having a maximum amplitude in one direction and a minimum

*Fig. 7.*

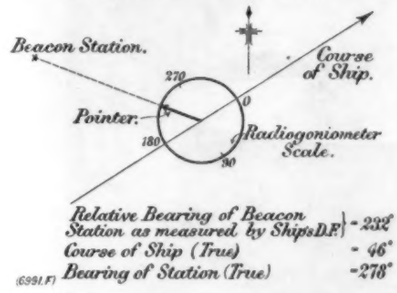

To AB Aerial.
To CD Aerial.
To CD Aerial.
To AB Aerial.
Radiogoniometer Coil connected to AB Aerial shown shaded.
Ditto to CD Aerial shown plain.
Search Coil shown thus:
Pointer is at right angles to Search Coil.
Then:-
If Aerial AB is in true NS line, zero of signals as determined by pointer, will give true direction of station.
If Aerial AB is in fore and aft line of ship, zero of signals will give bearing of station relative to ship's course.
(6991. E)

amplitude in a direction at right angles. Fig. 9 shows in plan approximately the magnetic field spreading out from an ordinary transmitting aerial of symmetrical form, and Fig. 10 that for directional transmitting stations of this type. A receiving station at C or D will receive the signals at maximum strength, and at A and B will receive the signals at minimum or zero strength. It may be convenient to regard this field as a broad beam of light having a maximum intensity at C D, and being obscured towards A and B. If, then, the field, or beam, shown in Fig. 10 is transmitted continuously while revolving at a fixed angular velocity with the zero, or obscuration, position passing through the line A B at definite times, a ship, knowing these times, will be able to find her bearing from the station by observing the time interval between the definite times mentioned and the time at which zero signals are received as the beam passes through north and south. For example, suppose the beam passes through the north-south line at successive exact minutes and that the watch in the ship has been exactly synchronised with the time at the direction-finding transmitting station; then if the ship receives zero signals (that is, loses the sound of the transmitter in her ordinary wireless receiving apparatus) at, say, each twentieth or fiftieth second during the first minute and succeeding minutes, then the bearing of the station is 20/60 or 50/60 of 360 deg., *i.e.*, 120 deg. or its reciprocal. By obtaining in the same manner her bearing from another directional transmitting station suitably placed and transmitting on a similar procedure immediately after the first station, the ship will be able to fix her

position. The principle of the transmitting apparatus just described is somewhat similar to that of the Bellini-Tosi direction-finding receiver. Other principles may be employed, but the method of operation in the ship will be more or less similar. At the present time Great Britain has no directional transmitting station in actual operation. Germany had three of these stations during the latter part of the war.

The advantages of the directional-finding station type are that for using it a ship requires no special wireless telegraphy apparatus beyond her ordinary installation and no special skill or training is required by the ship's staff. The apparatus in the shore station is worked under stable and favourable conditions, the loops in the station can be made large and thus give greater accuracy and the station can carry a skilled staff practised in taking bearings, thus taking responsibility and informing the ship. The disadvantages are that as ordinary wireless is used congestion on the wave lengths used by the stations may be caused when several ships are asking for positions, as any one set of directional-finding stations can only be used by one ship at a time. Further, ships can only use the stations at ranges well within the maximum of their transmitting installations. Also, if the shore stations

Fig. 8. EXAMPLE OF USE OF SHIP'S DIRECTIONAL APPARATUS.




signal the bearings only and not the position the ships will need, special charts or special tables of correction as the bearings obtained are the Great Circle bearings at the shore stations. Special charts, &c., will be unnecessary if the shore stations are organised so as to apply the corrections to the bearings and signal directly the position of the ship.

In the beacon station type the advantages are that any number of ships can obtain their bearing or fix their position simultaneously from one station or set of stations. A special wave-length can be allotted to the stations so that congestion with ordinary ship communications will not arise. Bearings and positions can be obtained at longer ranges, since the method is not limited by the ship's transmitting range and the stations may be made more powerful. The disadvantages of this type are that special directional receiving apparatus is required in a ship. This apparatus will need calibrating and occasional checking. Alterations in position of conducting material such as derricks, wire ropes, &c., in the immediate vicinity of the aerials may effect accuracy and necessitate re-calibration. The bearings are relative to the ship's head, and a ready method of obtaining the ship's course while actually determining the bearing must be available at her direction-finding installation. The ship's staff will need practice, and some technical skill in determining bearings, and must accept the responsibility for their accuracy. Ships must carry special charts or tables of special corrections as the bearings observed are those of the ship's end of the Great Circles.

The directional transmitting station type has the advantages that any number of ships can obtain their bearing or fix their positions simultaneously from one station or set of stations. Congestion of communications may be prevented by allotting the stations a special wave. Bearings and positions can be obtained at long ranges by making the stations sufficiently powerful. No special apparatus beyond a watch is required in the ship. Although some practice and a little skill are required in taking the observations, they may be made directly by the bridge staff without relying on the ship's wireless operators. The disadvantages of the type are that a special kind of watch is necessary, and for accurate bearings exact timing of this watch and exact observation of the interval are required. Moreover, specially-constructed shore stations are required, and these must be suitably placed to enable a fix to be made. Ships will also need special charts or special tables of corrections as the bearings obtained are the great circle bearings at the shore stations.

As to the reliability of bearings obtained by the methods above described, errors may arise from two causes; first by mistakes in estimation of the bearing on the part of the operator of the direction-finding receiver; secondly, by wave distortion, *i.e.*, the direction of arrival of the waves at the receiver being distorted from the direct line joining the transmitting and receiving station. With regard to the first, practice and experience are essential. Assuming that the directional set has been calibrated and the apparatus and aerials are well maintained, the maximum error in fixed stations with practised operators can be taken as 2 deg., and the average error as less than 1 deg. In ships'

Fig. 9.

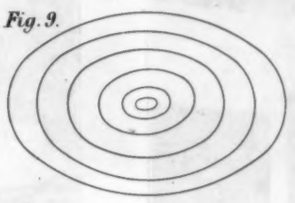
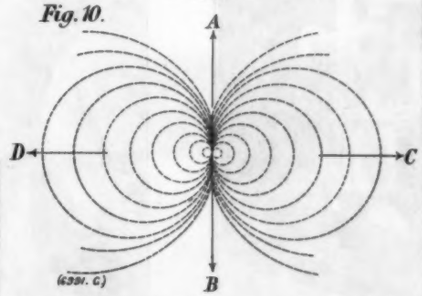


Fig. 10.




sets with small aerials the average error is slightly greater. With respect to the second cause errors due to wave distortion are negligible by day when the bearings are over water. Bearings obtained during day and from a station suitably placed so that no considerable line of land intervenes can be accepted as reliable if they are competently taken. These are the best conditions for direction-finding wireless working. If choice permits, bearings should be obtained by day in preference to night, as night errors up to 5 deg., and occasionally more, have been recorded. However, at short ranges of 50 miles to 100 miles over water the night errors are generally small, and bearings can be accepted as approximately correct. Times within 1 hour of sunset and sunrise should be avoided if possible. Bearings over land, unless it is flat, are less accurate than those over water. This is especially the case with night readings. High land close to and between the transmitter and receiver is a cause of error. Consequently, bearings should not be obtained when a vessel is close to high cliffs.

The estimated cost of a direction-finding receiving station is from 1,200*l.* to 1,500*l.*, and for a self-contained station with direction-finding receiver and transmitter complete from 3,000*l.* to 3,500*l.*, whilst that of a shore directional transmitting station available for long-range working and therefore requiring a powerful transmitting plant is approximately estimated at from 12,000*l.* to 15,000*l.* As regards ship's direction-finding sets, the apparatus required on board includes a twin direction-finding aerial system consisting either of fixed wires or of large rigid frames, a small room or cabinet (preferably not used for other purposes) and an operator. The complete receiving apparatus comprises wireless direction finder, tuning apparatus, receiving and amplifying set—these may be separate or combined; accumulator batteries for the receiver (4 volts to 6 volts, 50 ampere-hours to 100 ampere-hours), dry batteries, switches, spares, &c.; small charging and switchboard plant for accumulator batteries (these may be either charged from the electric mains of the ship or by small motor generator sets supplied from the ship's mains, or, if electric current is not available, a small internal-combustion generator will be required); and telephone or buzzer communications with the steering compass position, unless the receiving room is situated on the bridge with an immediate access to the steering compass. The cost of this apparatus with batteries, leading-in insulators and aerial is estimated at from 200*l.* to 300*l.* But this does not include cost of installing it.

## THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LTD., SHEFFIELD.

(*Concluded from page* 307.)

THE newer shops are on the north side of the Sheffield-road, and the first building encountered, to the left of the entrance is the pattern stores, a building in two bays, having a total capacity of 412,000 cub. ft. In this building are stored all patterns not immediately required in the foundry. Customers supplying their own patterns may rest assured that everything possible is done for their safety, the whole of the building being adequately protected by Grinnell sprinklers. This building was constructed during the war period, the patterns previously being stored in the building now known as the No. 5 steel warehouse. The construction of the building calls for no special description, but it is of interest to learn that it was originally part of the workshops of Messrs. Handyside, Derby, and was taken down and rebuilt on its present site by the works engineer's department of Messrs. Edgar Allen and Co. Adjoining the pattern stores, but entirely separated from it is located the garage in which is housed the firm's fleet of steam lorries and motor cars.

The pattern-makers shop is close by. This is a well-lighted and commodious building, constructed wholly of fire-resisting materials; it is adequately ventilated, and in the winter season heated by a low-pressure hot water installation. The machines are grouped at one end of the shop, a very complete installation of dust-collecting apparatus being provided; as a consequence, the shop is remarkably free from dust and shavings, this being conducive to the health of the workers and minimising the fire risks. The machines, with the exception of the lathes, are under-driven, the shafting being arranged in a basement and driven by electric motors. Special care has been taken to ensure proper natural lighting, all roof glass being arranged to give as nearly as possible a north light. A view in the pattern shop is reproduced in Fig. 20, on Plate XVI. A covered timber stores is built up against the south end of the shop, all the timber required being stored therein and well seasoned before use; a power-driven pendulum saw is used for cutting the boards and battens to the required lengths.

Near the pattern-makers' shop is situated a very important adjunct of the steel foundry, namely, the sand stores, in which the various sands are kept, mixed and conditioned; also a special laboratory, which has charge exclusively of all research and analytical work on sands and other materials used in the making of moulds and in the various phases of the manufacture of finished steel castings, tool steel, etc. This both relieves the works main laboratory and enables the firm to deal adequately with an essential feature of the manufacture of high-grade steel castings, one quite as vital as the actual manufacture in all its phases of the high-class steel itself.

Another and larger pattern-makers' shop is located as shown on the ground plan of the works, at the extreme west end and fronting Vulcan-road; in this shop are constructed the patterns for the casting of manganese special tramway and railway trackwork, and for the castings required in the manufacture of cement-making machinery.

The two steel foundries, a view in which is given in Fig. 21, on Plate XVI, are a characteristic

feature of the more modern part of the works. They have access to each other beneath a covered way, and measure overall a total length of 1,000 ft.; the width is 172 ft., and the height to eaves 32 ft. The eastern section of the Foundry, opened in 1914, is divided into four bays, one used for moulding on the side of a connecting bay down the centre, on which latter is a central normal gauge railway track, granite paving being laid between the rails. This track is continued into the western foundry, but in the latter the paving is made of reinforced granolithic concrete. The fourth bay is on the south side of the foundry, and is set apart for pattern layout, offices, melting and for mould drying stoves. This part of the foundry is equipped with four 3½-ton Tropenas converters, the liquid charge being delivered through movable landers from 8 ft. diameter cupolas, one to each pair of converters. The converters and cupolas are worked in pairs on alternate days, the linings being repaired between the working periods. The cupolas are arranged at a high level, the material used for charging being handled by two high-speed 2½-ton electric travelling cranes. The melted material is collected in a receiver, and from thence discharged as required into the converter, which is at ground level, the finished steel being poured into a ladle suspended in a pit by means of the overhead crane. The converters are blown by Roots positive blowers, and the cupolas by Keith-Blackman high speed fans; these are located in a separate room at the west end of the steel melting plant. The converter tilting gear is electrically actuated, the control house being conveniently situated between the pairs of vessels, the operator having complete protection from the heat. The controls for the blowers and fans are electrically operated, and are also situated at this point so as to be under the care of the operator in charge of the steel making. This plant is of particular interest from a steel foundry point of view, the Tropenas steel being obtained at a very high temperature, and remaining highly fluid for a comparatively long period, so much so that several heats are very frequently teemed in succession into a collecting ladle for casting pieces weighing up to 10 tons finished weight. Messrs Edgar Allen were the pioneers of, and very considerably developed this form of steel melting plant, the use of which has extended to all parts of the United Kingdom and the Continent, and also largely in the United States. Adjoining the blower room is situated a 3-ton Héroult electric melting furnace, the steel from which is used for steel castings and for making ingots of special grades.

The bulk of the casting is done at floor level, but for cylinders and all work necessary to be cast on end, a casting pit over 20 ft. in depth is used. This pit is arranged with a movable floor, which can be adjusted at any depth down to 20 ft. to suit the particular work in hand. The foundry is well equipped with electric overhead travelling cranes, electric jib cranes, hand cranes, runways, and every conceivable apparatus for the easy and expeditious handling of material from one part of the shop to another, and for inter-shop communication. One very noticeable feature is a fine electrically operated telpher runway conveying sand from the sand mixing shop at the extreme east end of the foundry to any part required, and the ingenious arrangements provided for tipping up the load at the point of delivery. The sand mixing plant is so arranged that the sand as brought from the sand stores in electric tip carts is discharged into bunkers, which feed into mills situated in a basement, and when thoroughly blended and mixed is carried up by elevators, discharged and allowed to fall by gravity through disintegrators into tip buckets, which are picked up by the electric telpher runway. A very large portion of the moulds and cores are dried in specially constructed ovens, fitted with sand sealed movable carriages, and heated by town gas. These are indicated on the general plan. The work being very largely of a jobbing nature, a considerable proportion of the moulding is done by hand methods, but wherever it is at all possible, both pneumatic and hydraulic moulding machines are used.

As already stated, the central roadway or communication way in the eastern foundry is continued through the western one. The north side of the latter has seven transverse bays, beneath which are situated pneumatic and hydraulic moulding machines, the whole of this portion of the foundry being laid out especially for machine moulding. The south side is arranged for jobbing work; at the time of our visit the installation of a new electric furnace was being proceeded with. Drying stoves are installed in this foundry, as previously described for the east foundry. Work in this portion of the foundry was commenced at the beginning of the present year.

The Edgar Allen foundries are amongst the lightest and best ventilated we have seen, the whole of the roof on the north side being glazed, the remainder consisting of corrugated-cement asbestos sheeting. Ample permanent provision has been made for keeping the roof glass clean, footwalks both inside and out being provided for this purpose. The handrailing to the outside footwalks is utilised for conveying water for the use of the window cleaners, a very simple but ingenious contrivance being employed to drain the pipes after use, so as to prevent damage by frost. The stanchions and crane gantry girders in the eastern foundry have been built up out of wide flange steel beams, but owing to the impossibility of obtaining further supplies of these sections this construction was not adhered to in the case of the western section, ordinary plate and lattice girder construction being here adopted. In the winter months the foundries are lighted by means of electric flame arc lamps suspended from the roof principals. To the north of the foundries described above are situated the fettling, finishing, and annealing shops, communicating with each other and with the foundry and machine shops by means of normal gauge track.

The method adopted in laying in the sidings and inter-shop railway communication deserves reference. Wherever the rails have been laid over ground also used by other vehicles, concrete construction, together with specially rolled grooved rails, has been adopted. The space between the rails and for each side, to whatever width considered necessary to carry the traffic, is paved with granite setts. This work was carried out so far back as 1912, and the maintenance, especially in view of the very heavy and continuous traffic, has been remarkably low. The condition of the roadways and sidings certainly appears to be remarkably good, far above the average state of affairs in a works.' This special form of construction was decided upon as the result of experience, and in view of the heavy and continuous traffic to be carried, a traffic which is compelled to follow certain specified routes.

The combined area of the fettling and finishing shops is 4,860 square yards, and that of the annealing shop 2,900 square yards. Fronting Vulcan Road, at the extreme north of the works, is situated the machine shop, an open space, 30 ft. in width, being left between this and the smiths' shop.

All the castings manufactured in either foundry are transported by either electric truck or railway wagon to the above shops, where the gates and runners are removed and the castings cleaned, and in some cases machined to suit the customer's requirements. For this purpose the fettling shops, one of which is shown in Fig. 22 on Plate XVI,

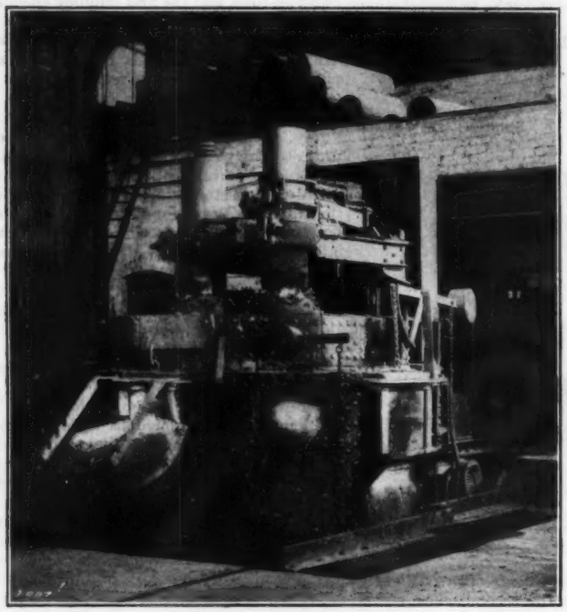


FIG. 28. HÉROULT ELECTRIC FURNACE.

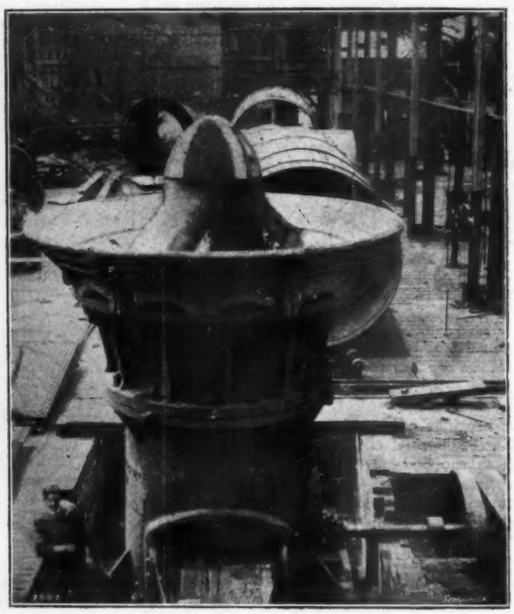


FIG. 29. GYRATORY CRUSHER IN COURSE OF ERECTION.

are well equipped with pneumatic power hammers, shot blast apparatus, oxy-acetylene cutting plant, and, of course, every requisite for hand fettling. Very considerable headway has been made in the use of shot blasting for cleaning the castings from sand, no fewer than nine separate chambers being in use for this purpose. The later installations of the shot blast plant are particularly well arranged; these installations, which have for their motive power compressed air at 40 lb. pressure, use chilled iron shot. The actual cleaning of the castings is carried out in isolated chambers constructed of strong sheet iron. The operator wears special clothing and a helmet, and a small low-pressure blower is used to convey fresh air to him through a valve in the helmet. The shot is projected by alternating motors; in the case of the compressors operating pneumatic hammers, the forging hammers in the smiths' shop and the moulding machines in the foundry, automatic electrical starting apparatus are provided, so arranged that when the pressure falls to a predetermined limit the motor automatically starts up, and when the pressure is restored to the maximum the motor is cut out. The air of course is pumped into a receiver.

The finishing shops are well equipped with all classes of grinding machinery, and other apparatus for the rough finishing of steel castings.

Between the foundries and the fettling shop is situated the annealing shop, equipped with modern gas-fired annealing furnaces. These furnaces, ten in number, are located down one side of the shop, and are in most instances fitted with sand sealed movable bogies for convenience in loading and unloading castings into the furnace chambers. Three Morgan gas producers, fitted with George feed working these furnaces, are located in a central position a few feet to the rear, the fuel being delivered by trucks on a siding alongside; the gas is carried by an underground brick culvert to the various furnaces, the products of combustion escaping by another underground brick culvert to a large iron chimney near the transformer house. Two of the latest furnaces call for special notice, one being a three-chamber continuous annealing furnace built by Messrs. King, Taudevin & Gregson Ltd., Sheffield, and the other the manganese steel heat treatment furnace, built by Messrs. Wincott Ltd. Two overhead electric travelling cranes are used for loading and unloading, and for moving the bogies in and out of the annealing furnaces.

The millwrights and electricians' shop is situated between the foundry and the annealing shop. It is equipped with an overhead crane, inspection pit and all necessary machinery for undertaking repairs to the works plant, and is under the control of the works engineer. All classes of repair work are dealt with in this shop, it being the policy of the firm to undertake all their own repair work, and the installation of new plant and buildings.

The foundry machine shop, illustrated in Fig. 23 in Plate XVI, is a well lighted and lofty building at the extreme north of the site; it fronts Vulcan Road, and covers an area of 4,200 square yards. The roof is arranged with glass entirely on one side, giving a true north light, the other side being covered by corrugated asbestos-cement sheeting. The side walls are steel framed, 9-in. brickwork in cement mortar being built in between stanchions, the whole of the materials being fire-resisting. The shop is heated by steam on the vacuum system. The shop is most completely equipped with machine tools for either finished or rough machining of steel castings to customers' requirements. The cutting tools are all made out of the particular brands of Messrs. Edgar Allen's special tool steels appropriate to the work to be done. The majority of the machines are direct driven by electric motors, only the smaller machines being grouped together and driven off a line-shaft. Within this shop is installed a very complete hydraulic testing plant for the testing of cast steel cylinders for hydraulic presses and other hydraulic machinery, of which Messrs. Edgar Allen have made a speciality. This plant is arranged to deal with the highest working pressures in everyday use. A tool room adjoins the shop in which are forged, ground and stored all tools required for the various machines. At the time of our visit the plant was in full activity machining large cast steel gear wheels, rolling-mill pinions, hydraulic press cylinders, and an infinite number of smaller castings in apparently endless variety, such as motor cases, central buffers and automatic couplings for foreign and colonial railways, axle boxes, etc. After machining, the work passes to the forwarding shop, located close to the works' offices, where it is carefully inspected, painted, packed into trucks, and collected at intervals by the works locomotives, and hauled into the Railway Company's sidings adjacent to the works.

The smiths' shop is located between the largest fettling and annealing shop and the machine shop. It contains a modern installation of pneumatic hammers, together with furnaces and ordinary smiths' hearths. In this shop is carried out all the smiths' work required in and about the works, and in addition such articles are forged as the shanks for central buffers and couplings, of which we saw a very large number in progress at the time of our visit. All the forging required for special tool steel is done at the Park View Forge, Owlerton, referred to on page 306 *ante*.

The Engineering Department, as will be seen from the general plan of the works, is located at the west side of the newer section of the works, and comprises a plating, machining, fitting and erecting shop, together covering an area of 15,404 square

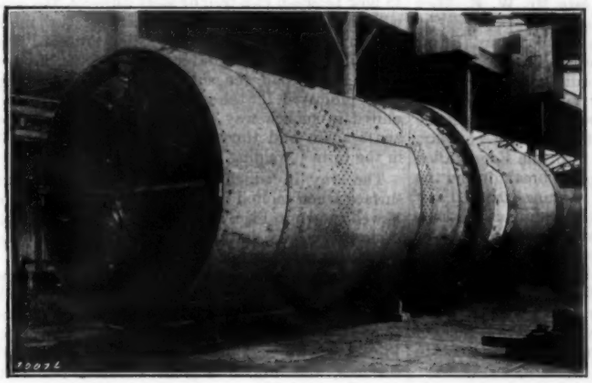


FIG. 30. PORTION OF A ROTARY KILN.

FIG. 31. STEEL BALL TUBE MILL.

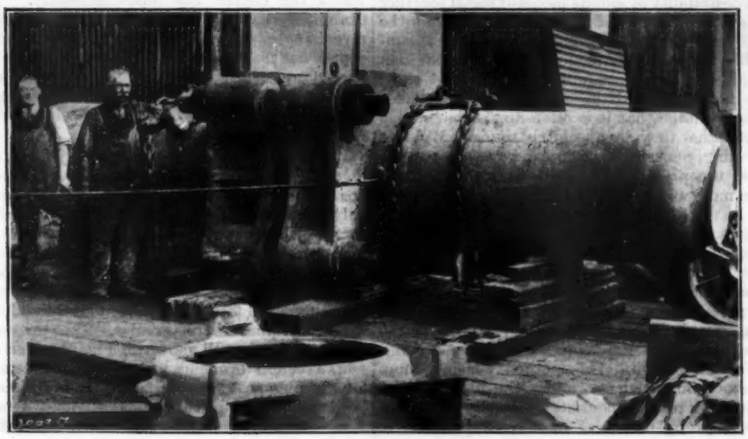


FIG. 32. HYDRAULIC TESTING OF TWO CYLINDERS.

means of a flexible pipe through a nozzle with considerable velocity upon the casting to be cleaned and afterwards, together with the sand, escapes through perforated gratings in the floor into hoppers beneath. A fan is used to work the shot and sand forward through a cyclone where separation takes place, the shot being returned to the operator and the sand carried forward through a stream of water to settling chambers below. Owing to the difficulty in digging out the sand from the settling chambers, and because of choked drains, the newer installations are fitted with air ejectors for forcing the sludge into tip carts, where the water is drained away and the solidified sludge afterwards carted away to tip. Considerable difficulty has been encountered and successfully overcome in dealing with this sludge, owing to its particularly tenacious nature, and we understand that the apparatus, which has been worked out by Messrs. Adams Hydraulics Ltd., York, together with the works engineer, is to be the subject of a patent. The compressors are electrically driven by direct coupled

yards. At the time of our visit the cement making machinery for the new works of the Humber Portland Cement Co., Ltd., was in course of completion. This department is engaged principally in the production of cement making machinery, crushers, coal screening plant, and general heavy engineering work, and is not to be confounded with the works' engineering department, which is solely occupied in the installation and maintenance of the buildings and plant. An idea of this department of Messrs. Edgar Allen's works and of the specialities with which they deal is afforded by the views Figs. 24 to 27 on Plate XVII, showing the light and the heavy plating shops, the machine and the erecting shops, and by Figs. 29 to 32 on pages 336 and 337 illustrating a gyratory crusher weighing about 80 tons in course of erection, a portion of a large rotary kiln 11 ft. 6 in. diameter tapering down to 10 ft., part of a steel ball tube mill, and two cylinders weighing over 7 tons each, being hydraulically tested before delivery. Fig. 28 on page 336 shows the works' Héroult electric furnace referred to above.

The Foundry Department offices are located on the east side of the works and front on to Vulcan-road. In the same block of buildings is located the Physical Laboratory fitted with a Buckton 50-ton hydraulic testing machine, an Izod impact machine, and other apparatus. Above this room are the foremen's dining room and the Exchange containing the switchboard and batteries controlling and operating the works and automatic telephone. Messrs. Edgar Allen's was one of the first telephones operated from an automatic switchboard to be installed in England outside Post Office control. The General Stores is also located in this block, consisting of three floors of reinforced concrete; in this are stored all the articles in general demand. As far as possible the stores is built and fitted with fire-proof materials, the walls and floors being of brickwork and reinforced concrete and the storage bins of sheet metal. One of the most interesting features in connection with the general stores is the 15-ton road weighbridge in the entrance gateway. This machine, designed and manufactured by Messrs. S. Denison & Son, Limited, has a steelyard arranged so as to print the net and tare weights in distinctive colours on loose tickets; at the same time it records every transaction on a locked endless tape. It is impossible to make a record unless the steelyard is in exact equilibrium, thereby preventing all possibility of mistake or fraud. The remainder of the block is set apart for time, cost and other offices.

All the shops with the exception of the foundry and annealing shop are heated by steam radiators on the vacuum system. Very great care and attention has been paid to the arrangement of sanitary appliances throughout the works. Drinking water is provided at convenient places. The whole of the shops are electrically lighted and in all cases the machinery is driven by the same agency. Every shop has a complete installation of electric overhead travelling cranes fully adequate to deal with the work carried out therein, and wherever possible dust collecting apparatus have been fixed to grinding machinery.

The area of the land upon which the buildings described above are situated is 23 acres.

The Park View Forge at Owlerton, which was acquired during the war, is situated on the borough boundary and covers 4,800 square yards. Since acquiring these works they have been re-arranged and improved. The installation consists of 6 steam hammers ranging from 5 cwts. to 2 tons; supplied with steam by two 30 ft. by 8 ft. Lancashire boilers. Offices, fitting shop, garage, etc., are suitably arranged to deal with the work passing through the forge, and recently a further piece of land at the south side has been purchased for the purpose of future extension.

Great interest is taken in the social side of the works. A magazine is printed and circulated every month, in which are chronicled the meetings of the various works' councils, the works' societies, sporting news and all items of interest to the staff and workmen. The material side is catered for in the excellent arrangement made in each shop for warming or cooking food brought in by the workpeople, and the provision of boiling water for tea-making at meal times. This is done free of charge, and for those requiring it, an excellent canteen is situated near the Vulcan-road entrance at the extreme west end of the works, where excellent cooked meals may be obtained at the lowest possible charge. The boys and youths are cared for by a welfare department under the charge of an ex-officer and everything possible is done for them in the way of sport. We understand that a field has just been purchased close by the works containing 9 acres which it is intended to lay out as a permanent sports ground for the use of the employees. The Edgar Allen L.S.D. Society devotes its efforts to the furtherance of the literary, social and dramatic side of social life, and annually stages a series of plays in one of the Sheffield theatres, the proceeds being devoted to the furtherance of the aims of the Edgar Allen Institute, established by the late Mr. W. E. Allen and referred to on page 272 *ante*.

In concluding this brief review of Messrs. Edgar Allen and Co.'s Imperial Steelworks, we may be allowed to state that the cordial relations which always existed between their most genial founder and the staff of his time are continued between the present directors and the staff of the present day, in other words, what we may term the Edgar Allen Traditions have endured without a break during the life of the establishment which has now exceeded half a century. That they will still endure is evident, for a glance at the different shops suffices to show that the men for their part, appear fully animated with the desire to keep up the excellent standing which their firm holds in the metallurgical and engineering world. They work with a will, have a contented and prosperous look, and there is none of the slack manner which, unfortunately, one meets in some other works.

## THE HYDE WELDING PROCESS.

THE desirability of joining pieces of metal together by other than mechanical means has brought the arts of welding, brazing and soldering to a considerable degree of perfection. Where great mechanical strength is required the third of these can be neglected, and the other two labour under the disadvantage that it is often almost impossible to be sure that they are absolutely sound. Welding and brazing, nevertheless, occupy a very important place in the processes of construction, and would be even more widely used if some of their drawbacks could be eliminated, because the possibility of making a firm and permanent metallic connection between two separate pieces without bolts, rivets or other devices is often of great advantage. Some few years ago a method of uniting iron and steel which partakes of the nature of both welding and of brazing was invented by Mr. A. C. Hyde of the Vactite Wire Co., Acton, and the Hyde Welding Co., Wolverhampton. This method which is now in regular commercial use, under the name of the Hyde welding process, consists essentially of uniting the surfaces by means of molten copper, but it differs from brazing in the fact that the copper impregnates the masses of metal to be joined and unites then in such a way that they cannot again be separated by heat.

The Hyde process is usually carried out simply by placing together the pieces to be joined with a small piece of copper wire or strip adjacent to but not between the joint and then raising the whole to the melting-point of copper while surrounded by an atmosphere of hydrogen. There is no difficulty about this in the case of articles of any ordinary size, as they are simply put in a muffle furnace through which hydrogen is passed, the gas being ignited and burnt as a small flame where it leaves the furnace. The surfaces need not be, and, indeed, are not, cleaned in any way beforehand, nor is any kind of flux used. The effect of the hydrogen is to reduce any rust or scale which may be present to the form of spongy metallic iron, which presents an admirable surface for the copper to penetrate. If a small piece of copper is placed on an iron plate and heated in an atmosphere of hydrogen to the melting-point of copper, the latter at once spreads out over the iron in a film. In such an operation the copper does not pass through any plastic stage. It is a case of either being melted or not being melted, the temperature margin between these two conditions being unrecordable.

The fluidity of the copper melted under such conditions is extremely high, and it spreads over the iron like petrol or water, penetrating the minutest crevices. This somewhat remarkable result cannot be due entirely to the deoxidising effect of the hydrogen, because equal results cannot be obtained when the atmosphere consists of other de-oxidising gases. The hydrogen appears to act as a flux, cleansing the surfaces and causing the copper to wet it and to flow freely over it. The exact cause of this action is obscure, but it may be connected with the phenomena of occlusion which is so well known in connection with the gas in question. By allowing copper, melted under such conditions to flow between two iron or steel surfaces, the latter will evidently be stuck together by the metal, and thus we have the Hyde welding process. But, as will be explained later, the process involves much more than the simple brazing or soldering effect indicated, for the surfaces become permanently united in such a way that they cannot be melted apart again and thus there is a certain propriety in the term "welding."

The way in which copper impregnates a steel surface when melted in an atmosphere of hydrogen is well shown in Figs. 1 to 6, Plate XVIII. In Fig. 1 is shown a high carbon (0·6 per cent.) steel wire "hyded" with copper and then drawn down, a process which obviously has no effect in loosening the adhesion of the coating. Indeed, wire can be drawn down to the finest gauges without dislocation. We shall refer again to this wire later. Fig. 2 shows a joint between two black scaly surfaces, and Fig. 3 a joint between two rusty surfaces, only one side being visible in the latter photograph. In both cases the oxides have been reduced to spongy metallic iron, the interstices of which the copper has filled perfectly. Micro-examination under the highest powers fails to reveal any gaps. It will also be noticed how the copper has insinuated itself between the crystalline aggregates of the steel. Fig. 4 shows a section through the steel parallel to the surface of the joint, and the way the copper has worked itself between the crystals is very evident.

In connection with the process of joining metals together in this way by means of copper, an important phenomenon is noticeable. The copper not only "solders" the surfaces together in the effective way which the photographs illustrate, but if the joint is maintained at a high temperature for any length of time after the copper has melted, the latter metal permeates the steel faces for a considerable depth forming an alloy of steel and copper with individual characteristics. The presence of such an alloy is well shown in Fig. 5, which represents a section through a joint which has "soaked" for some hours. The surface of the specimen has been etched with picric acid and shows a marked zone of impregnation but with somewhat undefined limits. Fig. 6 shows the same joint after repolishing and etching in sulphuric acid, which has attacked the steel but has hardly affected the alloy. It will be noticed how under the extended time of operation the original joint (looking similar to that of Fig. 7) is disappearing, the steel copper alloy growing through it. A further extension of time does as a matter of fact obliterate free or massive copper.

It is, however, by no means necessary that pure copper should be used to weld pieces of steel together or to get the effect just described. In Figs. 7 to 11 the effect of using an alloy of copper with 10 per cent. of tin is shown, the micrographs well illustrating the formation of the band of alloy already referred to. Fig. 7 shows the appearance of a joint between two pieces of steel, after a quarter of an hour's "soaking" in the muffle, and a much enlarged view of the same joint is given in Fig. 8. The band, which is just beginning to appear in Fig. 7 is seen to have largely developed in Fig. 9, which is reproduced to the same scale. This amount of development has taken place after twelve hours. After 24 hours, the appearance of the band is as shown in Fig. 10. Fig. 11 shows a section through the centre of

the joint to the same magnification as Fig. 8. The character of the structure has entirely altered, and there is no trace of any plane of cleavage between the two pieces of steel. Fig. 12 shows a section through an ordinary brazed joint. It will be seen that although the joint is perfect the spelter does not show any signs of having penetrated between the crystals of the steel, in the way in which copper does in the Hyde process.

Referring again to Fig. 1 illustrating the surface of a drawn wire, a very remarkable property may be noted of this and other "Hyded" articles. When such are exposed to damp and corrosive fumes which do not attack copper readily, such as sulphurous acid, they apparently go rusty in time like all other coppered articles although far less rapidly than the usual electro-coppered ones. If then the apparently rusty surface be rubbed and polished, the copper surface will come out again bright and new; it has neither peeled off nor otherwise disappeared. No doubt there are limits to this action, but the time of its serviceability is great compared with the life of most articles of to-day under the vicissitudes of everyday existence.

The usefulness of the process we have described as an adjunct to manufacturing methods is obvious.

*Fig. 13.*

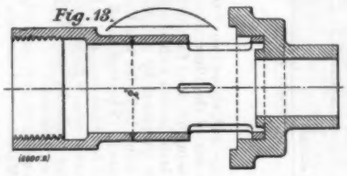
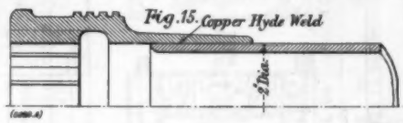


*Fig. 15. Copper Hyde Weld.*



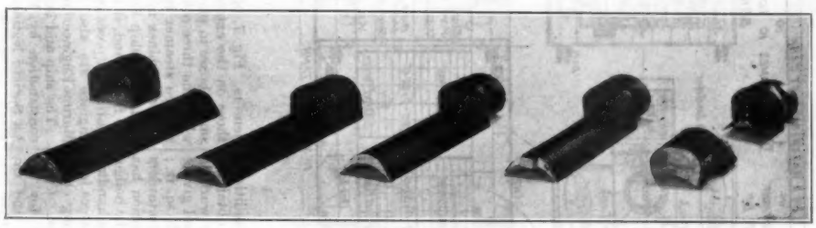


FIG. 14.

By its aid it is possible not only to simplify machining operations on complicated parts, but to produce parts which are to all intents and purposes composed of solid pieces of metal of such forms that they could not possibly be machined from the solid. The processes of brazing and autogenous welding are outclassed in such cases by the fact that they leave residues and disfigurements. The Hyde process is, indeed, already in commercial use for work of this kind, and the results are all that can be desired. There appears to be no difficulty in securing a perfect union by means of the copper even though the surfaces to be joined together are covered with mill scale or rust. Neither does any crevice seem too small for the copper to enter, We are assured that when a steel plug has been driven tightly into a bored hole, and a little copper melted round the joint in an atmosphere of hydrogen, for a second or two only the copper has found its way between the surfaces apparently in absolute contact and has permanently united them, a section through the junction afterwards showing a perfect union.

Fig. 13, annexed, shows an example of the practical utility of the process. The article illustrated is the cage or body of a high-speed centrifugal governor for small steam turbines. It will be obvious that the complete cage, which has to be virtually a solid piece of metal could not possibly be made from a single piece, as the machining of it would be out of the question. Made in two parts, however, as shown, the machining is simple and straightforward, and the parts are permanently united without the drawbacks which would attach to a screwed connection. The joint is perfectly neat and as strong as the solid metal, and being unfouled by flux residues requires no cleaning or dressing. Another example of the application of the Hyde process is shown in Fig. 14, which illustrates the attachment of distance pieces to the roots of turbine blades. The method of machining the blade together with the distance piece from the solid as a single article is very expensive, compared with the manufacture of the two parts separately. The Hyde process enables the cheapness of separate manufacture to be combined with the strength and convenience of the solid combination. The photograph shows a blade section after being pulled to destruction in a tensile testing machine, and it will be observed that the blade itself failed while there is no sign of dismemberment at the joint. We may mention that the process in question has been adopted by Messrs. Belliss and Morcom for the manufacture of impulse turbine blades of certain kinds, the blades shown in the photograph being of their design, and the number now made running into tens of thousands. Another example of commercial work is illustrated in Fig. 15, which shows a part section through the cardan shaft of the Lanchester motor car. The hollow tube forming the body of the shaft is joined to the splined ends in the manner shown, the joint being made by the Hyde process.

The forms of apparatus for effecting the process economically are varied, and depend much upon the articles to be treated.

At the Wolverhampton works hydrogen is supplied through mains from the adjoining works of the British Oxygen Co., and the muffler and other furnaces are fired by Mond Gas also from mains, thus placing the Hyde Company in a favourable position for economical working. The process can of course be "bottle fed" with hydrogen, but this method has obvious disadvantages.

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BRITISH PRODUCTION OF PIG IRON AND STEEL.—The production of pig-iron in July amounted to only 10,200 tons, compared with 386,000 tons in March and 750,600 tons in July last year. The production of steel ingots and castings amounted to 117,200 tons, compared with 359,100 tons in March and 78,900 tons in July last year. At the end of July, 15 blast furnaces were in operation, compared with 109 immediately before the coal stoppage and 299 last July. Of the pig-iron produced in July, 3,300 tons were basic, 2,600 tons foundry, 600 tons forge and 3,700 tons "other qualities."

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THE DICTO CALL SYSTEM.—A system of calling to members of a works staff wherever they may happen to be has been brought out by Messrs. Dictagraph Telephones, Limited, Amelia-road, Mitcham-road, Croydon, Surrey. This system consists in placing instruments of various kinds selected according to situation about the works or offices, so that the whole area is within audible distance of signals emitted by one or other of them. These instruments consist of bells, buzzers and horns, the former being used for quiet parts of the works, and the others for the noiser sections, or out-of-doors. These callers are connected with an operating instrument in the office, provided with eight code keys, sufficient to call by code 45 different individuals. The keys are depressed so as to read the code number of the person required, and a starting key is turned when the code number is called immediately and simultaneously all over the works. The starting key has seven positions, and the call will be automatically repeated by the instrument any number of times up to seven, according to the position in which this key is set by the operator. If a reply is received before all calls have been sounded, the operator can immediately cancel the remainder.

## CARGO STEAMERS FOR THE PARIS, LYONS AND MEDITERRANEAN RAILWAY.

THE cargo vessel illustrated by the elevation and deck plans reproduced on page 340, is one of eight building at the Cleveland Dockyard of Sir Raylton Dixon and Co., Limited, Middlesbrough-on-Tees, for the Paris, Lyons and Mediterranean Railway whose shipping business is managed by their subsidiary company, La Société Nationale d'Affrètements. The photograph reproduced in Fig. 1 on Plate XIX, which shows the general appearance of the "P.L.M. 20," was taken during the official trials of that vessel, when a speed of 11¼ knots was obtained on the measured mile with the ship in ballast draught, while with 7,500 tons deadweight on board, a mean speed of over 11½ knots was reached.

The vessel, which was designed by Captain Veyrat, of the Société Nationale d'Affrètements, has been built under special survey to receive Lloyd's highest classification as well as to comply with the requirements of the French shipping laws. Her principal dimensions are 400 ft. long, 56 ft. beam and 31 ft. moulded depth, while her deadweight carrying capacity is about 8,800 tons. As shown in the illustrations Figs. 3 to 5, on page 340, the vessel is of the single-deck type, and is constructed on the builders well-known system of cantilever framing, which has many advantages for the transport of coal, ore and other bulk cargoes. This system of construction, it may be pointed out, renders the ship completely self trimming and enables the holds, of which there are four in the vessel we are describing, to be constructed without any beams, pillars, wide stringers, web frames, or other obstructions. The construction is most clearly shown in the transverse section, Fig. 2 on Plate XIX, which also gives the scantlings. The left-hand part of this figure is a midship section through the No. 3 hold, while the right-hand portion is a section in way of the bunkers. The clear cargo space and the large hatchways should be particularly noticed, as also should be the top-side tanks which can be used either for water ballast or for carrying fuel oil, molasses or other liquid cargo, without interfering in any way with the cargo carried in the holds. Water ballast is also carried in the cellular double bottom, the aft-peak tank and in two large fore-peak tanks, as well as in the top-side tanks, the total ballast capacity of the ship being about 3,500 tons, which is sufficient to enable satisfactory voyages to be made under light conditions. A further advantage of the cantilever type of construction is that the top-side tanks are exempted from tonnage measurement.

Two masts and six derrick posts, fitted with "Cyclops" winches and derricks, are provided for loading and discharging the cargo, the centre derricks on the masts being arranged for heavy lifts up to 10 tons. The whole arrangements are designed so that the ship can be loaded and discharged either by means of grabs operated by cranes on shore or by means of her own gear. The four steel gantries visible in Fig. 1 are provided for securing the Hogg-Carr hatchway covers in the vertical position. Accommodation for the captain is provided in a large house on the lower bridge, a plan of which is given in Fig. 4, and over this is the wireless cabin, chart house and navigation bridge. The officers' accommodation is situated on the bridge deck, while engineers and petty officers are located on the poop deck at the casing sides, and the crew are berthed in the poop 'tween decks. Five boats in all are provided, two being suspended from Welin davits on the lower bridge, while two dinghies and a 14 ft. shore boat are carried on the after boat deck. The ship is lighted electrically throughout, and electric fans are fitted in the cabins; mechanical ventilation is provided in the crews' quarters and engine room.

On page 348 we illustrate the propelling machinery of the vessel which was constructed by the North-Eastern Marine Engineering Co., Limited, of Wallsend-on-Tyne. The main engine, which drives a single screw and is illustrated in Fig. 6, is of the quadruple-expansion type balanced on the Yarrow, Schlick and Tweedy system. The four cylinders are 23 in., 32½ in., 47 in. and 68. in diameter, with a piston stroke of 48 in., and the engine is capable of developing 2,800 i.h.p. at 75 r.p.m. when supplied with steam at 220 lb. per square inch. Steam is distributed to the high pressure and first intermediate pressure cylinders by means of piston valves, while double-ported slide valves fitted with balancing pistons are used for the second-intermediate and low-pressure cylinders. A Brown reversing engine of the steam-hydraulic type is mounted on the back of the main engine, and the thrust block is of the Michell single-collar type. The main condenser is of the "Contraflo" type and is provided with a kinetic air ejector; the air pump and two bilge pumps are driven from the high-pressure crosshead as can be seen in Fig. 6. This arrangement, it may be added, is necessary since the engines are placed right aft of the vessel. The auxiliaries fitted include two Weir feed pumps with an automatic control tank, a Gwynne centrifugal circulating pump driven by two enclosed engines with forced lubrication, a 300-ton ballast pump

# CANTILEVER SELF-TRIMMING CARGO STEAMER "P.L.M. 20."

CONSTRUCTED BY SIR RAYLTON DIXON AND CO., LIMITED, SHIPBUILDERS, MIDDLESBROUGH-ON-TEES.

FIG. 3.

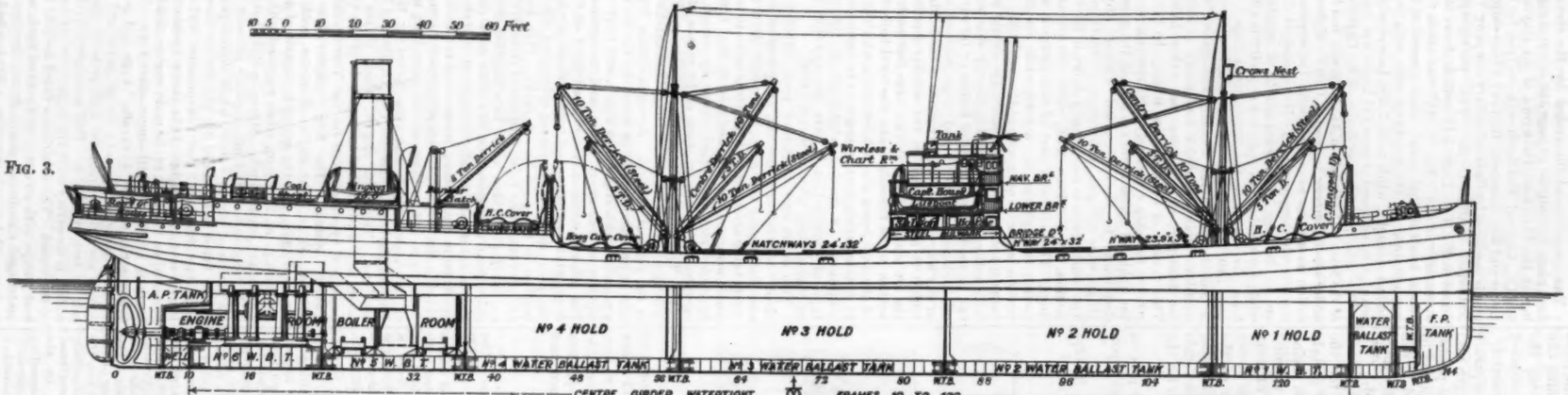



FIG. 4.

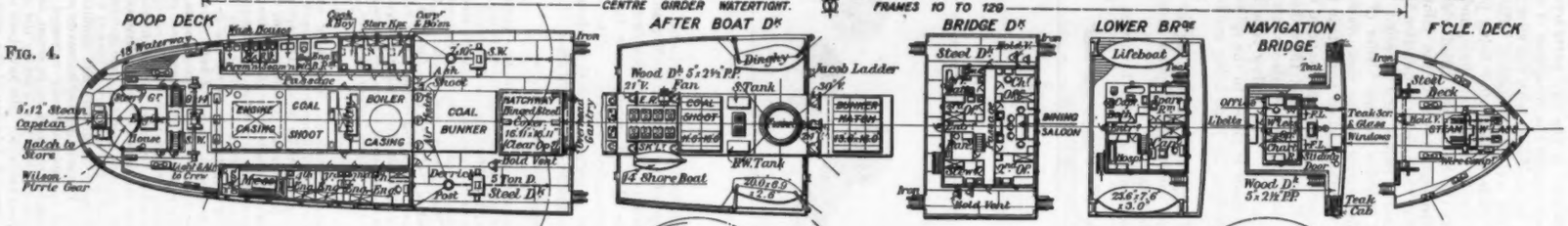
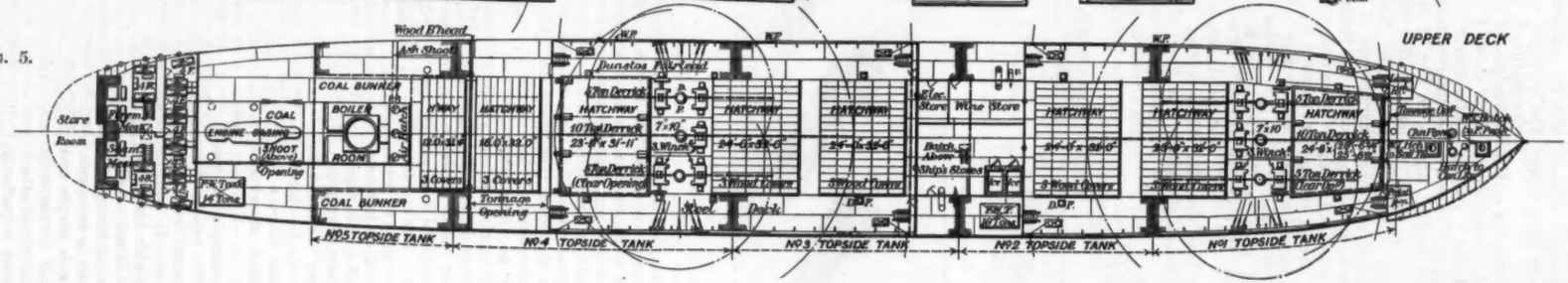



FIG. 5.




of the Woodeson type by Messrs. Clarke, Chapman and Co., Limited, an auxiliary feed pump by the same firm, a 35-ton "North-Eastern" evaporator, a "Contraflo" winch condenser, a feed heater, a gravitation feed-water filter, an injector for boiler feeding and a small duplex sanitary donkey pump. The deck machinery comprises a steam warping winch and a steam capstan aft, and a steam windlass forward, all of which were supplied by Messrs. Clarke, Chapman and Co., Ltd The steering gear, which is of the Wilson-Pirrie type with telemotor control, was constructed by Messrs. Donkin and Co.

Steam is supplied by three cylindrical, single-ended boilers, 15 ft. 6 in. in diameter by 12 ft. 6 in. long, this comparatively large boiler power being provided to give ample reserve power in adverse working conditions, such as occur when only inferior coal can be obtained. Each boiler has three furnaces arranged for working with the Howden system of forced draught and giving a total grate area for the three boilers of 174 sq. ft.; the total heating surface is 8,010 sq. ft. Scott's retarders are fitted to the boilers, and particular attention has been given to the matter of lagging, both of the boilers and of the engines and piping. The ashes are handled by a Crompton self-tipping hoist which discharges into a hopper inside the casing and through a long chute leading to the ship's side above the water line. Cumberland electrolytic apparatus is installed for the protection of the boilers against corrosion and the apparatus is also fitted to the main and auxiliary condensers. Fig. 7, on page 348, shows two of the boilers, those on the extreme left of the illustration with the smoke boxes in place being intended for the P.L.M. 20, while the three other large boilers were constructed for a cargo steamer to be propelled by double-reduction geared turbines now being built for the Union-Castle Mail Steamship Company. The two small boilers in the foreground, it may be mentioned, are to be used for heating purposes on motor vessels for which the Diesel engines are also being built by the North-Eastern Marine Engineering Co., Limited.

The ship and her machinery were supervised during construction by M. Marechal and Captain Veyrat of La Société Nationale d'Affrètements and by Mr. R. J. Eyres, of Messrs. Eyres and Bryers, Newcastle and Marseilles. We may add, in conclusion, that since the cantilever system of construction was first introduced by Sir Raylton Dixon and Co., Limited, they, and other shipbuilders, have produced vessels of this type with an aggregate deadweight tonnage of approximately 1,000,000.

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SALE OF AMERICAN NAVAL SHIPS.—The United States Navy Department, says *The Iron Age*, has sold to various buyers five dismantled naval vessels from which the metal will be salvaged as scrap. The sale prices are the following:—Cruiser Cincinnati, $15,100; gunboat, Castine, $12,500; cruiser Minneapolis, $36,000; cruiser, Marblehead, $11,100; cruiser, Raleigh, $10,800. The cargo steamer "Supply" was offered for sale, but no bids were made for her.

# DIE-SINKING MACHINE.

CONSTRUCTED BY MESSRS. BRYANT SYMONS AND CO., ENGINEERS, LONDON.

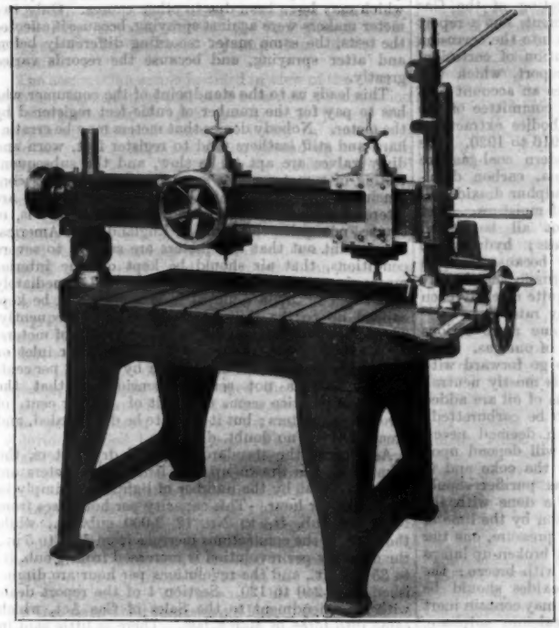


FIG. 1.

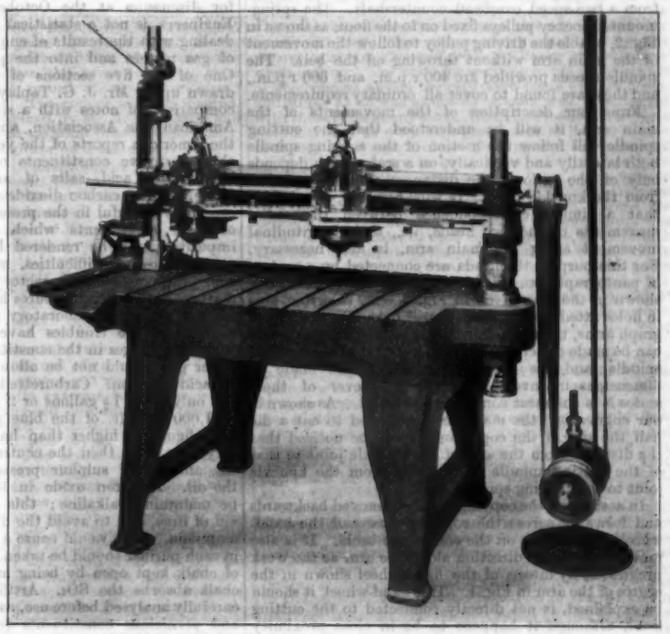


FIG. 2.

*Fig. 3.*

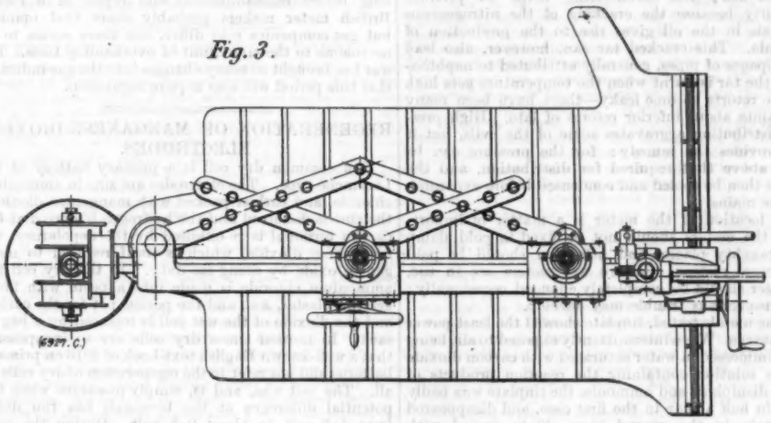
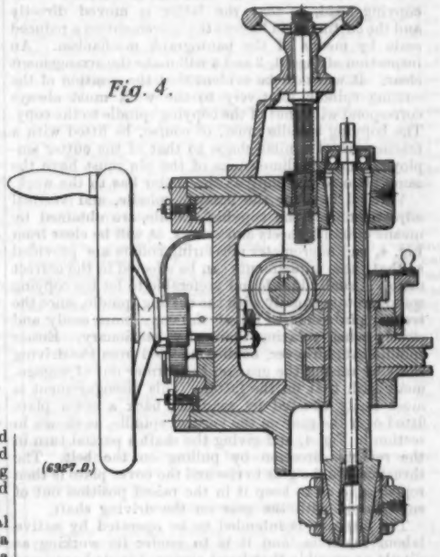



*Fig. 4.*




THE interesting and useful tool we illustrate above has been designed and constructed by Messrs. Bryant Symons and Co., 320, St. John-street, Clerkenwell, E.C. 1., to the order of the India Office, for cutting the dies used in drop-forging work. Messrs. Symons, it will be remembered, are occupied mainly in the production of machine tools and light plant for special purposes, in which a high degree of accuracy is required, and most of their productions, including the tool we are about to describe, contain a number of ingenious devices not common in general engineering practice. Much of their work is, however, of a confidential nature, so that the solutions they have supplied to many interesting mechanical problems cannot be made public, but those cases in which the publication of design details is possible will usually repay a fairly careful study.

The die-sinking machine, the general appearance of which is illustrated in Figs. 1 and 2, is a development of a pantograph profiling and engraving machine, a number of which have been supplied to the Royal Mints in London and Calcutta, and to other Government Departments, but it is, of course, suitable for a heavier class of work. As will be seen from our illustrations, the machine comprises a pair of standards carrying a rectangular cast-iron table, the upper surface of which is provided with tee slots. On one end of the table is a pivoted knuckle joint on which the main arm of the machine is mounted so that it can be turned through a small angle in either the vertical or horizontal planes. The method of mounting this end of the arm can be most clearly seen on the right-hand side of Fig. 2, which also shows the screw and ring nut provided to enable the arm to be raised or lowered vertically to suit work of different heights.

The other end of the arm is clamped to a vertical telescopic tube in which is a rod surrounded by a helical spring and terminating, at its lower end, in a fork carrying a Skefko ball bearing. The outer ring of this bearing rests on the table, and practically the whole of the weight of the free end of the arm is transmitted to it through the medium of the helical spring. Screwed on to the upper end of the rod above referred to, which projects above the upper end of the tube, is a steel cylinder having a rack cut on one side; this cylinder is a sliding fit in a sleeve, the lower end of which is clamped on to the telescopic tube. The sleeve carries a pinion gearing with the rack on the cylinder, and by turning this pinion, by means of the lever shown in the top right-hand corner of Fig. 1, the outer end of the arm can be raised or lowered, or, rather, the whole arm can be turned through a small angle in the vertical plane.

Lateral movement, *i.e.*, angular motion in the horizontal plane, is imparted to the arm by means of a carriage gibbed on to sliding ways formed on one end of the table, as shown in both the half-tone engravings. A vertical blade pivoted to the carriage fits into a slotted bracket projecting from the arm, the arrangement permitting the latter to move in the arc of a circle while the carriage travels in a straight line. The carriage is operated by means of a hand wheel, rack and pinion, as will be obvious from the illustrations. In this motion, the arm runs on the Skefko bearing above mentioned, and it should be noted that, owing to the well-known self-aligning property of this particular bearing, the outer ring always remains in perfect line contact with the table irrespective of the slight tilting of the telescopic tube which takes place when the end of the arm is raised or lowered. The rectangular objects at the lower end of the tube, which hide the ball bearing in our illustrations, are wipers composed of stiff rubber sheeting, and their object is to remove chips, and other foreign matter, from the path of the bearing. The horizontal rod seen projecting from the end of the arm on the right of Fig. 1 is provided to serve as a convenient handle for assisting the movement of the arm either vertically or horizontally.

Mounted on the arm are two heads, both of which are of exactly similar construction, that nearest the knuckle joint being the cutting head and the other, the

copying head. Each head, one of which is shown in section in Fig. 4, carries a vertical spindle running in adjustable bearings and fitted with a collet chuck; a ball thrust washer is fitted at the upper end of each spindle to take the vertical thrust. The spindles are driven by helical gearing from a shaft which is itself driven by belt from a two-speed overhead countershaft. The spring-mounted jockey pulleys fixed on to the floor, as shown in Fig. 2, enable the driving pulley to follow the movement of the main arm without throwing off the belt. The spindle speeds provided are 400 r.p.m. and 600 r.p.m., and these are found to cover all ordinary requirements.

From our description of the movements of the main arm, it will be understood that the cutting spindle will follow the motion of the copying spindle both laterally and vertically, on a scale which depends only on the ratio of the distances of those spindles from the knuckle joint. It will, however, be obvious that a similar correspondence between the radial movements of the two heads, *i.e.*, their longitudinal movement along the main arm, is also necessary. For this purpose the heads are connected by a system of pantograph arms visible in Fig. 2, but more clearly shown in the plan given in Fig. 3. By inserting pins in holes fitted with hardened steel bushes in the pantograph arms, the radial movement of the cutting spindle can be made either $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$, $\frac{1}{8}$, or $\frac{3}{4}$ of that of the copying spindle, and the copy must therefore be made to dimensions in inverse ratio to whichever of these scales it is the most convenient to adopt. As shown in our engravings, the machine is arranged to cut a die half the size of the copy, and it will be noticed that the distance from the axis of the knuckle joint to that of the cutting spindle is half that from the knuckle joint to the copying spindle.

In actual use, the copying spindle is moved backwards and forwards across the copy by means of the hand-wheel and carriage on the end of the table. It is also moved in a radial direction along the arm as the work progresses, by means of the hand-wheel shown in the centre of the arm in Fig. 1. This hand-wheel, it should be explained, is not directly connected to the cutting head, although it happens to be in close proximity to the latter in the illustration. Actually it is connected by reduction gearing to a pinion gearing with a rack which slides on the arm and is attached to the copying head, so that the latter is moved directly and the cutting head follows the movement on a reduced scale by means of the pantograph mechanism. An inspection of Figs. 1, 3 and 4 will make the arrangement clear. It will now be evident that the position of the cutting spindle relatively to the work must always correspond with that of the copying spindle to the copy. The copying spindle must, of course, be fitted with a tracing pin of similar shape to that of the cutter employed, and the dimensions of the pin must have the same ratio to the copy as the cutter has to the work.

Vertical feed for the cutting spindle, and vertical adjustment for the copying spindle, are obtained by means of hand-wheels and screws, as will be clear from Fig. 4, and micrometer measuring collars are provided so that these adjustments can be effected in the correct ratio. Usually it is found preferable to let the copying spindle rotate equally with the cutting spindle, since the tracing pin seems to follow the copy more easily and closely when rotating than when stationary. Either spindle can, however, be disconnected from the driving shaft by raising the gear on the former out of engagement with that on the latter. This disengagement is most easily effected by swinging back a cover plate fitted over the gear on the vertical spindle, as shown in section in Fig. 4, and giving the shaft a partial turn in the reverse direction by pulling on the belt. The thrust causes the gear to rise and the cover plate is then replaced so as to keep it in the raised position out of engagement with the gear on the driving shaft.

The machine is intended to be operated by native labour in India, and it is to render its working as simple as possible that hand-operated feeds have been employed; either radial or transverse feeds can, however, be made automatic if desired. The copy is usually an iron casting, not necessarily machined, but it is possible to employ a hard wood copy if the latter is carefully handled. If a light finishing cut is used, very little hand work will be necessary to render the die ready for use. The machine is obviously particularly useful where a number of dies of the same shape and size have to be cut, but for cutting only one die, the time and labour saving effected by it is quite sufficient to justify its employment. The slotted portion of the table, in the machine illustrated, measures 3 ft. 4 in. by 2 ft. 4 in., and dies can be cut on it up to about 12 in. square, measured on the actual impression. About 1 h.p. is required to drive the tool.

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INSTITUTION OF NAVAL ARCHITECTS' SCHOLARSHIP (1921) AND EARL OF DURHAM PRIZE.—The Institution of Naval Architects' Scholarship (1921) has been awarded by the Council of the Institution to Mr. S. A. Hodges, and the Earl of Durham Prize to Mr. T. A. Davies, both of H.M. Dockyard, Portsmouth.

## THE LIFE OF COAL-GAS METERS.

THE report of the Joint Committee of the Institution of Gas Engineers and of the Society of British Gas Industries, on the "Life of Gas Meters," which has now been released for publication and will come up for discussion at the October meeting of the Gas Engineers, is not a statistical document, but a report dealing with the results of enquiries into the corrosion of gas meters and into the prevention of corrosion. One of the five sections of the report, which was drawn up by Mr. J. G. Taplay, gives an account of a comparison of notes with a similar committee of the American Gas Association, and embodies extracts of the American reports of the years 1916 to 1920. The chief corrosive constituents of modern coal-gas are hydrocyanic acid, salts of ammonia, carbon disulphide, oxygen, carbon dioxide and sulphur dioxide, all especially harmful in the presence of moisture. Most of these constituents which cannot all be styled impurities, can be rendered harmless; hydrocyanic acid still causes difficulties, mainly because it is an acid—the poisonous character of prussic acid hardly matters—but successful cures have quite recently been worked out in the laboratory at any rate.

Many of the troubles have become more serious with the changes in the constitution of our gas. Blue water gas should not be allowed to go forward with an acid reaction. Carburetted gas is mostly neutral, but only when 1½ gallons or 2 gallons of oil are added to 1,000 cub. ft. of the blue gas to be carburetted; that figure is higher than has been deemed necessary, but even then the neutrality will depend upon the amount of sulphur present in the coke and in the oil. The iron oxide in the gas purifier should be maintained alkaline; this can be done with the aid of lime, and to avoid the liberation by the lime of ammonia, which would cause a back pressure, one tier in each purifier should be taken up by broken-up lumps of chalk kept open by being mixed with breeze; the chalk absorbs the $SO_2$. Artificial oxides should be carefully analysed before use, as they may contain inert and pernicious constituents (*e.g.*, calcium sulphate, sulphuric acid, &c.). The sulphur dioxide in the blue gas may be removed by washing the gas with a solution of soda ash; the carburetting helps to produce neutrality because the cracking of the nitrogeneous materials in the oil gives rise to the production of ammonia. This cracked tar can, however, also lead to stoppages of pipes, generally attributed to naphthalene; the tar is burnt when the temperature gets high and the retorts become leaky—there have been many complaints about inferior retorts of late. High pressure distribution aggravates some of the evils, but it also provides the remedy; for the pressure can be raised above that required for distribution, and the gas can then be cooled and condensed before expansion into the mains.

The location of the meter is a matter of importance; the meters should not be fixed in cold, damp and draughty places, and attention should be paid to external rusting. Where wet meters are in use, the water should be completely changed occasionally; otherwise serious trouble may develop.

Of the metals tested, tinplate showed the least power of resistance. When intermittently exposed to air, being partly immersed in water saturated with carbon dioxide or in a solution containing the reaction products of carbon disulphide and ammonia, the tinplate was badly pitted in half a year in the first case, and disappeared completely in the second case. Plate coated with lead or with an alloy of zinc and lead, gave much better results, and some special metals, such as armco (pure) iron coated with lead-tin alloy, came through the test in a very fair condition. Aluminium passed the tests unaffected.

With respect to the spraying of the meters for their lubrication and protection, the Committee has been making inquiries which, on the whole, seem favourable to the spraying. Plants for spraying, by hand or machinery, have been installed by more than a hundred gas undertakings. The oil spray is not only to clean and to lubricate the slide-valves, but also to maintain the suppleness of the diaphragm and to coat the interior of the case with a protective film. A heavy oil of paraffin base should answer, provided it will not polymerise and turn sticky; a light oil might tend to wash the dressing off the leather and the grease from the stuffing boxes. Much will depend upon the suitability of the oil; the Committee recommends a mineral oil of high boiling point and density (preferably above 0·85) which will not ultimately leave a gummy residue. One of the specific questions put on the inquiry sheet was: "If you atomise or vaporise paraffin burning oil (such as Royal day light) into your mains, are you able to trace any benefit to consumers' meters thereby?" and the replies were mostly in the affirmative. One firm has resorted to spraying for as long as 12 years with the object of eliminating naphthalene and keeping the diaphragms in good condition; another firm have had four sprayed diaphragms, in continuous use since 1907, and still in good condition. Only a few replies were to the contrary; one considered all cleansing oils as detrimental to the life of the meter; another complained that they had had to exchange an enormous number of meters in consequence of leaky stuffing boxes—an unusual complaint which may have been due to other causes. Only two meter makers were against spraying, because it affected the tests, the same meter recording differently before and after spraying, and because the records varied greatly.

This leads us to the standpoint of the consumer who has to pay for the number of cubic feet registered by the meter. Nobody denies that meters may be erratic; hard and stiff leathers tend to register fast, worn and dirty valves are apt to be slow, and the subsequent testing of a meter under suspicion is not always convincing. The details of the American reports are interesting in this respect, though the practice is, of course, not quite the same in England as in America. They point out that idle meters are subject to severe conditions, that air should be kept off the interior mechanism, and the inlet and outlet should immediately be "capped" upon removal from service and be kept capped up to the time of testing and subsequently. The total effect of applying oil to the valves of meters, by a spray or fog introduced into the meter inlet or outlet, was to make the oiled meter by about 1 per cent. faster. This is not serious, considering that the American practice seems to admit of ± 2 per cent. of error in gas meters; but it is not to be disregarded, and greater errors, no doubt, do occur.

As regards the standardisation of dry meters, the Committee has drawn up new lists. The meters are now rated, not by the number of lights, but simply in cubic feet per hour. This capacity per hour rises from No. 1, 30 cub. ft., to No. 12, 3,000 cub. ft., while the bores of the connections increase from ⅜ in. to 5 in., the capacity per revolution is increased from ¼ cub. ft. to 25 cub. ft., and the revolutions per hour are diminished from 240 to 120. Section 4 of the report deals with an amendment to the Sales of Gas Act, which came into force in March last. There is little said in the report on the actual life of gas meters. The Americans consider a period of 10 years sufficiently long before re-examination and repair of a meter. British meter makers probably share that opinion, but gas companies may differ, and there seems to be no rule as to the time limit of overhauling tests. The war has brought so many changes into the gas industry, that this period will also require regulation.

## REGENERATION OF MANGANESE-DIOXIDE ELECTRODES.

THE common dry cell is a primary battery of the Leclanché type. The electrodes are zinc in ammonium chloride, and carbon packed with manganese dioxide; the zinc is dissolved and the hydrogen liberated at the carbon terminal is re-oxidised by the depolariser, the manganese dioxide, which is itself reduced to manganese oxide by doing its duty. In the dry cell the ammonium chloride is made into a paste with flour, gelatin, plaster, &c., and the porous pot for the carbon and the dioxide of the wet cell is replaced by a bag or sack. In normal times dry cells are so inexpensive that a well-known English text-book of 1916 on primary batteries did not refer to the regeneration of dry cells at all. The cell was, and is, simply discarded when the potential difference at the terminals has run down from 1·5 volt to about 0·8 volt. During the war, however, manganese became so scanty and precious on the Continent, that attempts were made to regenerate dry cells, *i.e.*, the exhausted depolariser. The regeneration, one might think, simply means a re-oxidation of the manganese oxide. That is only partly correct. Recent experiments, notably by R. Nowotny, of Vienna (*Elektrotechnik und Maschinenbau*, July 17, pages 349 to 354), tend to show that the cleaning of the electrodes and the removal of deposits clogging the pores of the pot or bag and of the depolariser itself are more important than the actual re-oxidation of the manganese. This is fortunate; for the re-oxidation cannot be effected by simple chemical means, and the effective electrolytic treatment could hardly survive war conditions.

In his tests Nowotny takes new and old cells, short-circuits them through 20 ohms and determines the potentials at intervals for 40 days, when the cells will be exhausted. The two processes first tried, of R. Lohnstein and of R. Gollmer, treat the bags with sulphuric acid, a rather strong acid being used for two days in the former case, a weaker acid (10 per cent.) for two hours followed by washing and drying for weeks in the latter, more elaborate method. Nowotny observed that the treatment indeed raised the potential difference to two volts, because, he suggests, the newly-built up cell is really a zinc-carbon couple in sulphuric acid, as long as the acid has not decomposed the ammonium chloride. But the subsequent exhaustion under his test conditions was rather rapid, whilst under

the less severe intermittent service of the cells in practice fairly satisfactory results are said to have been obtained. He ascribes the success rather to the solubility in the acid of the double zinc-ammonium chloride—a salt which forms an incrustation in the cell, being insoluble in the cold ammonium chloride of the cell—and to the clearing of the pores than to any noteworthy re-oxidation of the manganese oxide. Clogging is also produced by impurities of the cell materials.

The assumption seems justified in view of the efficacy of other regeneration processes in which a reoxidation of manganese oxide could hardly take place. The superficially-cleansed bags are boiled in ammonium chloride; the dried mass is then ground up and again compressed in bags. The treatment, which was adopted in Germany, is not economical, since it practically means making new electrodes out of old materials; but the essence of the process seems to lie in the cleaning and boiling in ammonium chloride. Nowotny boiled the cleaned bags twice for two hours in a solution of 10 per cent., and then washed the bags; the so-treated cells gave 88 per cent. of the watt-hours of new cells. Moreover, Olivier, an official in the German telegraph department, who had, since 1917, regenerated some 12,000 dry cells by an electrolytic method, admitted, early in 1920, that the electrolytic oxidation of the manganese did not appear to be essential to his process, by which he prolonged the life of the cells by 12 months and more. He charges the cleaned cells like accumulators, in water to which ammonium chloride is added, by currents of 0·2 ampere for 20 hours renewing the electrolyte. A similar electrolytic process of Friedrich was adopted by the department in their works at Berlin, Hamburg and Dortmund, after trying various other processes which proved failures. Nowotny himself made his cell-charging experiments in sulphuric acid. He noticed a temporary rise in the electromotive force and a decided increase in the proportion of manganese dioxide in the depolariser, as one would expect; all the same, his regenerated cells did not keep their superiority long. It is interesting to read that in the stress of time some small German stations had to rely entirely on regenerated cells, and that they could work with them. Thus, regeneration of dry cells by simple means seems possible.

## EXPLOSION OF A BREWING COPPER.

A PRELIMINARY inquiry has been conducted by the Board of Trade under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the explosion of a brewer's copper which occurred on December 22, 1920, at the Leigh Brewery, Leigh, Lancashire, owned by Messrs. George Shaw and Co., Limited. The report on the examination made by Mr. Alfred E. Coe, Surveyor to the Board of Trade, has recently been published, and to it we are indebted for the following particulars.

The explosion appears to have been of a serious nature, inasmuch as Mr. W. H. Boyes, assistant engineer at the brewery, and Mr. Morris Sabor, forwarding clerk for Messrs. Hamlyn and Co., brewers' grain merchants, of Manchester, were both severely scalded and died from their injuries and shock at the Leigh Infirmary, the former on December 24 and the latter at 8.30 p.m. on December 22, the day of the explosion.

The copper was 12 ft. in diameter internally, and the shell, which was 9 ft. in height, was made up of wrought-steel plates $\frac{3}{8}$ in. in thickness, connected together by single butt straps $\frac{1}{2}$ in. in thickness and 5 in. in breadth, fitted externally, and single-riveted with rivets $\frac{3}{4}$ in. in diameter, pitched $2\frac{3}{4}$ in. apart. The dished base was made up of four steel plates also $\frac{3}{8}$ in. in thickness, and fitted with single butt strap joints, and was connected to the shell by a single-riveted lap seam. An internal wrought steel plate, riveted to the base and supported by the usual stays, formed a steam jacket at the lower extremity. An angle iron ring, 3 in. by 3 in. by $\frac{1}{2}$ in., was riveted to the top of the shell, and to this ring the cover was attached by 128 Muntz metal bolts $\frac{3}{4}$ in. in diameter. The domed cover was made up of eight sheets of copper 10 S.W.G., or ·128 in. in thickness, riveted together by copper rivets $\frac{1}{2}$ in. in diameter pitched $1\frac{1}{2}$ in. apart, and a brass stiffening ring 5 in. broad and $\frac{7}{16}$ in. in thickness was fitted above the flange by which the cover was secured to the angle ring, the bolts passing through the ring cover and angle bar. A manhole 20 in. in diameter was cut in the cover, and compensation was provided by a brass ring riveted to the cover, which was fitted with a hinged lid secured by dog stays. A throat piece 24 in. in diameter was riveted to the top of the cover, and attached to this was a thin sheet steel trunk or uptake of similar diameter, made from plates $\frac{1}{4}$ in. in thickness. This uptake was about 13 ft. in height and conveyed any steam generated in the copper to the exhaust line of pipes, a butterfly valve being fitted to the branch pipe leading from the uptake to the exhaust pipe. At the top of the uptake two safety valves, each 5 in. in diameter—one of the lever and one of the dead-weight type—were fitted, the former valve discharging into the exhaust pipe and the exhaust from the latter leading through a pipe into the atmosphere. A small atmospheric non-return valve was also fitted to the cover on the top of the uptake.

A coil, composed of seven turns of 3-in. copper pipe, was fitted at the bottom of the copper for heating the liquid, and was supplied with steam at a pressure of 100 lb. per square inch, a similar pressure being applied to the steam jacket. The valve for controlling the steam to the coil was operated by means of gearing from the third floor of the building. A pressure gauge, graded from zero to 10 lb. per square inch, was fitted to the uptake on the copper, and a high-pressure gauge was fitted to the main steam pipe line on the fourth floor.

The copper was made by Messrs. Thomas Ryder and Co., brewers' engineers, Manchester, in 1904, and was therefore about 16 years old at the date of the explosion. Early in September, 1920, 16 of the bolts which were used to secure the cover in place, were renewed. There was no record of any other repair having been carried out. The copper was not insured, but was periodically examined by Mr. John Hutton and Mr. Minchin, the head and assistant brewer respectively, and by Mr. Holt, the engineer at the brewery.

The explosion was of a violent nature; the whole of the bolts securing the cover fractured, and the cover was forced up to the roof, the uptake immediately above the cover being severely telescoped.

With regard to the cause of the explosion, the bolts which were used to secure the cover in place were in a defective condition, and it is probable that the safety valves were either completely choked or partly so, and a pressure was generated in the copper sufficiently high to cause the failure of the bolts as described above and in the "general remarks" appended to the report furnished by Mr. Coe.

In these remarks it is stated that the copper from which the explosion occurred was one of three similar vessels fitted in the brewing department and was known as No. 2 copper. On account of its extreme height the copper and its connections extended through three floors of the brewery. It was used for boiling new beer, technically known as "wort," the copper being sometimes called a "wort pan." The operation of brewing is described in the report as follows: "Malt and liquor are mixed in the mash tun and are then drained away through a number of tubes into a small tank, from whence the mixture is run into the copper at a temperature of about 170 deg. F. The copper is steam jacketed at the base, and is covered with about 3 in. of non-conducting material and fitted with a steam coil to keep the liquor at a high temperature, and ultimately to boil it. As soon as the coil is covered by the liquor entering the copper, steam is turned on to the coil, the valve being opened sufficient to admit enough steam to keep the liquor at a temperature approaching boiling point. While the liquor is running into the copper through the filling pipe, dry hops are added through the manhole in varying quantities to suit the intended gravity of the brew. It is usual to run into the copper sufficient liquor for 150 barrels, that is 5,400 gallons, and this quantity is obtained when the level in the copper has reached a height about 2 ft. below the manhole, and the brewer has a wooden gauge or 'dipstick' which is inserted through the manhole to ascertain the height of the liquor in the copper. When the requisite quantity of liquor is present in the copper the supply is shut off from the mash tun and the filling cock is shut. The manhole door is closed down and secured, and the steam is then turned fully on to the coil. The brewer then closes the butterfly valve or damper fitted in the exhaust trunk, and when steam issues from the test cock closes this and waits for the safety valves to lift, indicating that the maximum pressure has been reached in the copper, and he then partly closes the steam valve to the coil and regulates the amount of opening by the pressure indicated on the steam pressure gauge."

After referring to other matters, Mr. Coe goes on to say that the brewing plant was under the general supervision of Mr. Hutton, the head brewer, who on the morning of the explosion visited the various parts of the building in which the brewing plant is situated, and was present in the copper room about five minutes before the explosion took place. He did not notice anything unusual at the time, and apparently nothing was wrong with the copper in question, No. 2. He was called away and subsequently heard the sound of the explosion, and on returning to the brewhouse found that the copper had failed, as mentioned in the report. Search was then made to ascertain if anyone had been injured, and it was found that two men, Mr. Boyes and Mr. Sabor, both of whom were on the second floor when the explosion occurred, had been severely scalded by the liquor which had overflowed from the copper after the cover had been blown away, and found its way down through an annular space, about 3 in. in width, round the shell of the copper, into the second floor of the building. Mr. Boyes was at work on this floor, and Mr. Sabor was apparently sitting on the window sill immediately below the copper, having his lunch preparatory to starting work at noon. Both men had their injuries attended to at the brewery and were then removed to the infirmary, where they both succumbed to scalds and shock.

After dealing at some length with the evidence of the assistant brewer, the report states that some time early in December both the brewer and his assistant noticed that steam was leaking from the cover of No. 2 copper, and the matter was reported to Mr. Holt, the engineer. He states that he removed 16 bolts with the help of the late Mr. Boyes, and found that the whole of these were badly stretched, and that two of them were almost at breaking point at the root of the thread. He renewed the whole of these bolts, and this stopped the leakage from the joint. Mr. Holt had held the position of engineer at the brewery for the last four years and stated that no other repair to No. 2 copper had been carried out during that period, and the joint on the cover had not been remade during that time.

The report then deals with the question of the safety valves and the evidence of Mr. Ryder, a member of the firm who made the copper, and who stated that he found, on examining the valves, a considerable quantity of saturated hops in each safety valve chest and took out about a couple of handfuls from each. It was not unusual, in his experience, to find an accumulation of hops in valve chests, although these were fitted at a height of 13 ft. above the top of the copper. In his opinion these hops were carried upwards into the uptake when the hops were inserted into the copper in a dry state, and these were subsequently saturated by the vapour or steam given off from the liquor in the copper when boiling. The bolts for securing in place the covers of the coppers at the brewery were made of cast brass, and so far as he was aware no trouble was experienced with these bolts at any time. When first made the coppers were intended to work at a pressure of $1\frac{1}{2}$ lb. per square inch, but some months later the pressure was increased to $2\frac{1}{2}$ lb. per square inch, and the safety valves were accordingly adjusted, arrangements being made for one safety valve to lift at a pressure of $2\frac{1}{2}$ lb. per square inch and the other at 3 lb. per square inch. When the coppers were first erected a mercurial pressure gauge was fitted to the uptake of each copper in way of the fourth floor, to be in sight of the brewers in that room, and to act as a check on the ordinary "Bourdon" pressure gauge which was fitted at a lower point on the uptake. Mr. Ryder found that these gauges had been removed at some time prior to the explosion, and no record appeared to have been kept as to when or why they had been removed.

Mr. Coe states in his report that he made a careful examination of the bolts which had been used to secure the cover in place, and this revealed the fact that many of them were apparently in a defective condition before the explosion took place. The existence of old flaws could be distinctly seen, and the mechanical tests which were afterwards made from several of the broken bolts confirmed this view. The whole of the broken bolts could not be traced, several of them having been lost at the time of the explosion.

The remainder of the report deals with the tests made of the bolts and to various matters raised by the engineer and by the makers of the copper, and the Surveyor states in conclusion that the owners of the brewery are now proposing to convert their coppers into open boiling coppers, to dispense with any appreciable pressure in the apparatus, the butterfly valves or dampers being removed from the system, the outlet to the atmosphere being free. In the meantime the safety valves of the other coppers have been overhauled and new bolts have been fitted to the covers.

Mr. Carlton, Engineer Surveyor-in-Chief to the Board of Trade, in his "observations" respecting his assistant's report, makes the following remarks: "In view of the obstruction by hops to which the valves were liable and the low pressure at which they were set to lift, it seems probable that the copper was frequently subjected to a higher pressure than was intended. The Bourdon pressure gauge was inaccurate, and such over-pressure would not have been detected by its means. It was unfortunate that the mercurial gauge, originally fitted, had been removed, as this type of gauge is sensitive and accurate, and particularly well adapted for the registration of low pressures such as occurred in the copper; and if the process of boiling described is continued it should be replaced.

"The bolts securing the cover were possibly lacking to some extent in toughness and ductility, which are desirable qualities in material subjected to varying tensile stresses. They were, however, under normal conditions, not unduly stressed, and it is probable that their complete and almost simultaneous breakdown was in some measure due to over-pressure in the copper, and also to a fatigued condition resulting from the heavy stresses, cross-breaking to some considerable extent, set up by repeated over-pressure in the copper, and distortion of the thin cover.

"The explosion caused the loss of two lives in very distressing circumstances, and it is hoped that such serious consequences will have some effect in drawing attention to the necessity of maintaining relief valves and pressure gauges in good working order.

"On the whole it would be safer to convert the coppers into open vessels if such conversion will give efficient working results."

PLATE GIRDER SPANS FOR NEW ZEALAND.—The Public Works Department of New Zealand invites tenders until October 4 next for the supply and delivery of plate girder spans for the Tarawera and Rangitaiki bridges. The estimated net finished weight of the girders, including holding-down bolts, is about 200 tons. A copy of the conditions of tender, specification and blue prints may be seen by United Kingdom manufacturers interested on application to the Department of Overseas Trade (Room 50A), 35, Old Queen-street, S.W.1.

RESISTANCE OF SELENIUM.—Taking electrodes of gold—which alone of all the metals does not seem to be attacked by liquid selenium—H. Pélabon (*Comptes Rendus*) has determined the electric resistance of fused selenium. As the selenium is heated its resistance falls off rapidly. He observed at temperatures of 390 deg., 412 deg., 465 deg., 540 deg., 645 deg. and 690 deg. C. specific resistances of 76,650 ohms, 38,925 ohms, 12,300 ohms, 2,247 ohms, 237 ohms and 88 ohms. Plotted on a logarithmic scale these figures lie on a straight line. In cooling, Pélabon observed the same values again down to about 300 deg. C.; then the diminution of the resistance was so sudden that determinations could not be made. Selenium is generally stated to melt at 217 deg. C.; it boils at 690 deg. C., according to Pélabon.

# STILL OIL ENGINE FOR MARINE PROPULSION.

CONSTRUCTED BY MESSRS. SCOTTS SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GREENOCK.

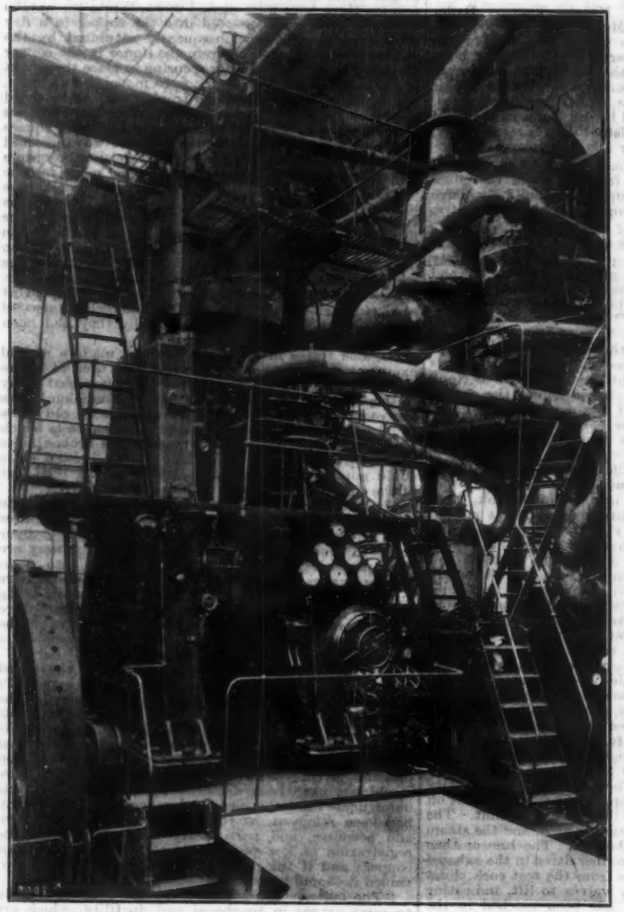


FIG. 1.

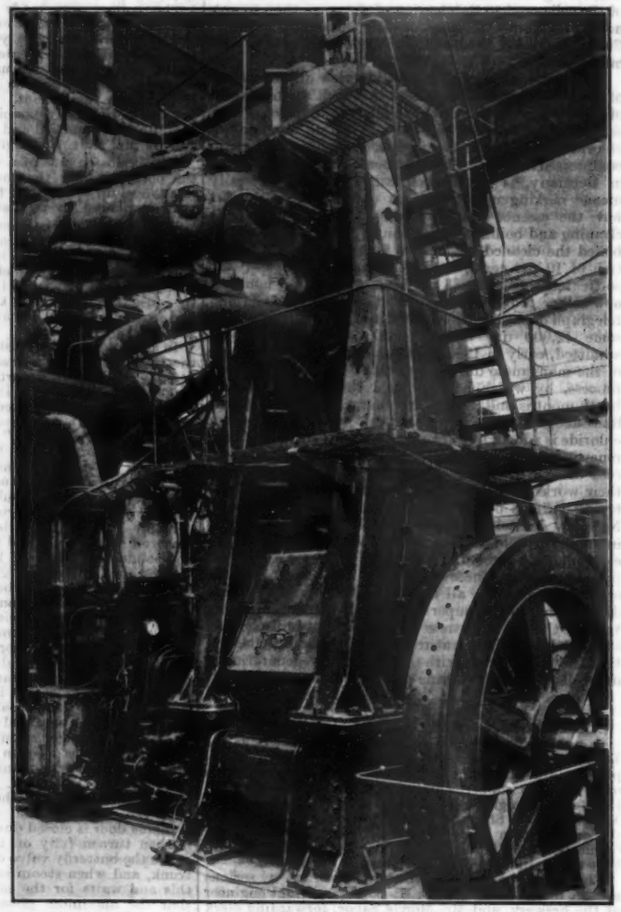


FIG. 2.

A DEPUTATION of engineers representing Government and commercial interests in France recently visited this country to report on the Still engine, and in the course of their investigations, carried out tests on the experimental engine designed and built by Messrs. Scotts' Shipbuilding and Engineering Company, Limited, of Greenock. This engine is, we understand, the largest of the type so far constructed, and is of the slow running marine type suitable for the merchant service. It has been constructed under license of the Still Engine Company, Limited, 7, Princes Street, Westminster.

Before giving extracts from the report of this deputation upon these trials, a brief description of the engine itself will be of interest. We hope in a future issue, to publish particulars of other trials with drawings and detailed description of the engine.

As is generally known, the Still Oil Engine is a combination of an oil engine and a steam engine. The main source of power is oil consumed within a cylinder for the down stroke, operating in this particular machine on the two cycle principle, while steam forms a supplementary source of power, being used for the up stroke. The primary aim of the design is to reduce heat losses to a practical minimum. This is accomplished by raising steam as follows:—(*a*) By heat taken up by the water circulating in the cylinder jacket under working steam pressure. All of this heat goes to form steam; (*b*) By heat recovered from the exhaust gases by means of regenerators and feed water heaters. Water is evaporated in the former and the feed water is raised to boiler temperature in the latter.

To carry this out in practice, it is necessary to provide certain steam plant, and to provide steam inlet and exhaust valves for the cylinders. There are, however, certain compensating advantages, and the most marked of these is that no compressed air is required for starting and manœuvring, because under these conditions, the engine is really a steam

TABLE I.

*Main Still Cylinder:* Stroke, 36 in. (915 mm.); bore, 22 in. (560 mm.); area (combustion), 380·13 sq. in. (2,455 sq. cm.); piston rod, 6¼ in. diameter (159 mm.); Low pressure steam area, 349·45 sq. in. (2,250 sq. cm.).
*Auxiliary High-Pressure Cylinder:* Stroke, 22 in. (560 mm.); bore, 14 in. (356 mm.).

NOTE.—Steam M.E.P. is given as referred to the combustion cylinder. The factors are:

High-pressure steam M.E.P. ÷ 4·05 = Referred M.E.P.
Low-pressure steam M.E.P. ÷ 1·09 = Referred M.E.P.
Brake horse-power = Weight (pounds) × Revolutions ÷ 500.

*Trials, May* 10, 1921, *Abstract.*

| — | — | Overload. | | Full Load. | | Half Load. | | Quarter Load. | |
|---|---|---|---|---|---|---|---|---|---|
| | | British. | Metric. | British. | Metric. | British. | Metric. | British. | Metric. |
| 1 | Average combustion M.E.P. | 88·9 lb./sq. in. | 6·25 kg./cm.² | 81·22 | 5·7 | 54·2 | 3·81 | 40·27 | 2·83 |
| 2 | Average steam M.E.P. referred H.P. | 4·43 lb./sq. in. | 0·311 kg./cm.² | 3·80 | 0·267 | 1·26 | 0·0885 | 0·28 | 0·0197 |
| 3 | Average steam M.E.P. referred L.P. | 7·36 lb./sq. in. | 0·516 kg./cm.² | 6·23 | 0·437 | 3·6 | 0·253 | 1·05 | 0·074 |
| 4 | Total M.E.P. | 100·69 lb./sq. in. | 7·07 kg./cm.² | 91·25 | 6·41 | 59·06 | 4·15 | 41·6 | 2·926 |
| 5 | Revolutions per minute | 128·1 | — | 124·3 | — | 103·0 | — | 84·0 | — |
| 6 | Brake load | 1,500 lb. | 680 kg. | 1,380 | 626 | 850 | 386 | 530 | 240 |
| 7 | Steam boiler pressure | 112·0 lb./sq. in. | 7·85 kg./cm.² | 100·0 | 7·0 | 108·0 | 7·57 | 104·0 | 7·3 |
| 8 | H.P. receiver | 75·0 lb./sq. in. | 5·26 kg./cm.² | 57·0 | 4·0 | 23·5 | 1·65 | — | — |
| 9 | L.P. receiver | 11·0 lb./sq. in. | 7·72 kg./cm.² | 5·5 | 0·386 | 0·4 | 0·028 | − 5·55 | − 0·39 |
| 10 | Vacuum | 28·0 in. Hg. | 711 mm. Hg. | 27·5 | 698·0 | 26·6 | 675·0 | 25·3 | 642·0 |
| 11 | Barometer | 29·87 in. | 758·0 mm. | 29·87 in. | 758·0 | 29·87 in. | 758·0 | 29·87 in. | 758·0 |
| 12 | Water evaporated per hour | 950·0 lb. | 430·0 Hg. | 807·0 | 366·0 | 388·0 | 176·0 | 77·0 | 34·9 |
| 13 | Scavenge air pressure | 49·0 in. water | 91·5 mm. Hg. | 46·0 | 86·0 | 40·0 | 75·0 | 38·0 | 71·0 |
| 14 | H.P. for scavenging | 15·4 | 15·6 | 14·1 | 14·3 | 12·0 | 12·18 | 10·6 | 10·75 |
| 15 | Combustion, i.h.p. | 394·0 | 400·0 | 349·5 | 354·5 | 192·5 | 195·2 | 116·5 | 118·2 |
| 16 | Total i.h.p. | 446·0 | 453·0 | 392·0 | 398·0 | 210·0 | 213·0 | 120·0 | 121·8 |
| 17 | Engine b.h.p. | 384·0 | 389·0 | 343·0 | 348·0 | 174·0 | 177·0 | 88·5 | 89·7 |
| 18 | Net b.h.p. | 368·6 | 373·4 | 329·0 | 333·7 | 162·5 | 165·0 | 78·0 | 79·0 |
| 19 | Oil per hour | 146·6 lb. | 66·5 kg. | 123·4 | 56·0 | 64·0 | 29·05 | 38·7 | 16·65 |
| 20 | Oil/Combn., i.h.p.-hour | 0·372 lb. | 166·2 grm. | 0·353 | 158·0 | 0·332 | 148·4 | 0·315 | 140·7 |
| 21 | Oil/Total i.h.p.-hour | 0·329 lb. | 147·0 grm. | 0·315 | 140·7 | 0·305 | 136·6 | 0·306 | 136·8 |
| 22 | Oil/engine b.h.p.-hour | 0·382 lb. | 171·0 grm. | 0·360 | 161·0 | 0·367 | 164·0 | 0·415 | 185·5 |
| 23 | Oil/Net b.h.p.-hour | 0·398 lb. | 178·0 grm. | 0·375 | 167·5 | 0·394 | 176·0 | 0·471 | 212·0 |
| 24 | Efficiency per cent., combustion i.h.p. | 42·9 | — | 44·8 | — | 46·2 | — | 46·1 | — |
| 25 | Efficiency per cent., engine b.h.p. | 37·0 | — | 39·4 | — | 38·5 | — | 34·0 | — |
| 26 | Efficiency per cent., net b.h.p. | 35·5 | — | 37·7 | — | 35·8 | — | 30·0 | — |

*Note.*—Lines 17, 22, 25 refer to the engine and all the auxiliaries except the scavenge blower, separately driven. Lines 18, 23, 26 are the net figures after deducting the blower power given in line 14.

engine with the flexibility always associated with that class of machine. This makes the engine very easy to handle and, of course, allows it to run at very low speeds. Another direct result of this combination is that a low compression pressure can be used with absolute certainty of "firing," the reason being that the cylinder walls are kept at steam temperature by water circulating in the jacket from the regenerator. During compression the air charge picks up heat from the walls instead of being cooled by them for the greater portion of the stroke, as occurs in the Diesel engine. The relatively low compression pressure enables lighter scantlings to be used, or alternatively provides a larger margin of safety, as the maximum pressure possible in the cylinder is a function of the compression pressure. It further provides a useful margin for any loss of pressure in service, as the pressure used in practice in this engine, although considerably below that of the Diesel engine practice, is well above the minimum pressure which will produce the temperature required to ensure combustion. In Messrs. Scotts' engine, we understand the normal compression pressure used is about 300 lb. per square inch. The engine on which the tests have been carried out at Messrs. Scotts works, is shown in Fig. 1 and 2, from which some idea of the experimental plant will be obtained. The engine is a single cylinder unit of 22 in. diameter and 36 in. stroke. It is coupled to a Heenan and Froude water brake. An electric motor is also provided to absorb power when running astern. Scavenging air is supplied by a motor-driven Reavell turbo blower. This discharges into a large tank to minimise the fluctuations of pressure, whence it passes to the cylinder by way of the bedplate and columns.

The exhaust gases pass from the engine to a regenerator (in this case a small Cochran boiler) set above the level of the combustion cylinder jackets. The gases finally pass through a feed heater on their way to the atmosphere. Steam is taken from the regenerator to the engine and expanded in two stages to the condenser. To effect this, owing to the experimental engine having only a single cylinder, it has been necessary to provide a small auxiliary steam cylinder. This forms the high pressure cylinder and the lower end of the main cylinder serves as the low pressure cylinder, whence the steam passes to the condenser. Compounding in, say, a six cylinder engine would be secured by using the lower ends of two combustion cylinders as high pressure steam cylinders and those of the other four similar cylinders as low pressure steam cylinders.

The combustion cylinder jacket, as has been stated, is kept under steam pressure and temperature by a circulation of water from the regenerator through the jacket and back again; no pump is necessary, as the circulation is a natural thermal one. Thus, when the engine is cold and the burner under the regenerator is lighted, the water begins to circulate from the regenerator to the cylinder jacket, heating up the latter gradually until the desired steam temperature and pressure are reached. When the engine is running and the regenerator burner has been shut off, the circulation reverses and takes place from the cylinder jacket to the regenerator because of the heat added to the jacket water through the cylinder liner, and the steam produced finds its way by the pipes provided to the regenerator. The steam and exhaust valves are of the piston type, and are operated by oil under pressure.

All the pumps necessary for the engine, except the scavenge blower, viz., the forced lubrication pump, valve gear oil pump, circulating pump, air pump and feed pump are driven from the main engine shaft. A complete system of oil measuring and water measuring tanks are provided, the former being visible above the regenerator level. The others are placed in the space beneath the regenerator.

Special provision is made in the design of the engine for expansion and contraction due to heat, the combustion cylinder being held by a joint at its lower end only, thus being free to grow upwards as the temperature rises. The steam end of the cylinder is also free to expand. The method of transmitting the combustion load by means of four through bolts attached to the columns is indicated by the illustrations.

The control wheels are shown in Fig. 1, the larger wheel being employed to stop and reverse the engine, while the smaller wheel is used for the speed regulation of the engine under the control of the governor. From the illustrations it will be gathered that there is only one opening at the top of the combustion cylinder, viz., the opening taking the fuel valve. The cylinder has no cover in the ordinary sense of the word, and there is an entire absence of cams and rods about the cylinder, even the fuel valve operating automatically by the action of the fuel pump. The engine works on the solid injection principle, that is to say, no air is used to atomise the oil during injection into the cylinder.

The following engineers formed the deputation to which we referred: M. André, chief engineer (Materials and Running) of the Madrid, Saragossa and Alicante Railway; M. Bochet, engineer to the Central Office of the French Thomson-Houston Company; M. Boris, Engineer-Captain, French Navy and Member of the Reparations Committee; M. Bourges, Engineer-Commander French Navy; M. Terrasse, chief engineer of the La Société Anonyme des Ateliers et Chantiers de la Loire. These engineers superintended, on May 10, tests of the engine illustrated, and have since drawn up a report of which we reproduce certain sections below, translated into English and British measurements. We also give, on page 344, Table I, summarising the results. The flexibility and ease of starting and control were particularly remarked upon. It may be stated that the extracts are taken from both an interim and a final report, the former being signed by the whole deputation, and the latter by M. Bochet on behalf of the deputation.

The following are the extracts referred to:—

The fuel consumption figures . . . . are extremely low. One can estimate that with a good Diesel engine, four-cycle, the quantity of oil consumed would have been at least 10 per cent., and with a two-stroke engine 20 per cent. higher. It is further necessary to take into account the point that a provisional single-cylinder installation causes losses in efficiency which would not be found in a complete installation intended for normal service. In particular the high-pressure steam cylinder was isolated from the group and did not completely benefit by the favourable conditions in which the steam expands in a Still cylinder. (The pressure pump for the oil required to operate the steam valve gear was driven by a small auxiliary engine with a high steam consumption.)* It is justifiable therefore to estimate that in a normal installation the fuel consumption at equal power would be still further reduced.

. . . . The Still engine is a machine of the greatest interest which seems able to render great service in all cases where it is necessary to obtain great facility of manœuvre, powerful starting torque and large variation of load.

During the full-load trial it will be seen that the power was 348 metric h.p. (343 b.h.p.), from which has to be deducted 14·3 h.p. (14·1 b.h.p.) absorbed by the scavenge pump, leaving 333·7 h.p. (329 b.h.p.) available at the engine shaft. Fuel consumption corresponding was 56 kg. 400 (123·4 lb.) per hour, that is to say, a consumption of 168 grm. per h.p. per hour (0·360 lb. per b.h.p./hour).

The consumption on an overload of 11 per cent. corresponding to a net power of 374·4 h.p., *i.e.*, 390 − 15·6 (368·6 b.h.p., *i.e.*, 384 − 15·4) was 66 kg. 75 (146·6 lb.) per hour, that is to say, 177 grm. per h.p. per hour (0·398 lb./b.h.p./hour).

At ½-load, with a net power of 164·8 h.p., *i.e.*, 177 − 12·2 (162·5, *i.e.*, 174·5 − 12), the consumption was 29 kg. 4 (64 lb.), that is to say, 176 grm. per h.p. per hour (0·394 lb. per b.h.p./hour).

At ¼-load, 78·75 h.p. net, *i.e.*, 89·5 − 10·75 (78 net, *i.e.*, 88·5 − 10·5), the consumption was 210 grm. (0·47 lb.).

During the full-power test the boiler pressure very slightly dropped, the consumption as measured is a little low; it is on the contrary a little high in the case of the overload, and slightly less than reality in the case of ½-load and ¼-load trials.

It is interesting to note that the indicated power of the engine on the combustion side during full load trial was 354 h.p. (349 i.h.p.) at a mean pressure of 5 kg. 68 (81·2 lb. M.E.P.), the shaft power was then 333·7 h.p. (329 b.h.p.). It will be seen that the addition of the steam side was not entirely able to compensate for the friction losses.

*Indicated Power, Combustion, Brake Power.*—The total indicated pressure, taking into account the steam side, was 6 kg. 382 (91·25 lb. per square inch), corresponding to a total power of 398 h.p. (392 i.h.p.). The mechanical losses are therefore 64·3 h.p. (63 b.h.p.), the recovery by the steam produced 41·5 h.p.† (? 44 h.p. = 43 b.h.p.), the efficiency of the engine

$$R = \frac{333 \cdot 7}{398} = 0 \cdot 84$$

This figure is high, but it must be remembered that the engine used mechanical injection, doing away with the auxiliary compressor.

The recovery at full load of the steam side corresponds to 41·5 i.h.p.† (? 44 = 43 i.h.p.). We will assume that the power necessary to overcome friction is entirely borne by the combustion side; the power recovered by the steam will then be totally transmitted to the shaft.

We see that this recovered power represents about 12 per cent. of the brake power of the engine.

The quantity of steam produced per hour at full load was about 367 kg. (807 lb.), which corresponds to a consumption in the engine of 8 kg. 900 (19·6 lb.) per i.h.p. The boiler pressure was 7 kg. (100 lb.), approximately, the corresponding temperature of the water was 170 deg. C. (338 deg. F.).

The evaporation of 367 kg. (807 lb.) per hour represents approximately a recovery of 240,000 calories (9,500,000 B.Th.U.). The fuel oil supplied to the engine, about 560,000 calories (22,000,000 B.Th.U.), of which 226,000 calories (8,930,000 B.Th.U.) were converted into work in the combustion cylinder (40 per cent.).

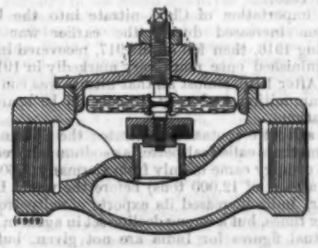
Of the 334,000 calories (13,270,000 B.Th.U.) remaining, there have been used for the formation of steam about 240,000 calories (9,500,000 B.Th.U.), that is to say, 43 per cent. of the heat produced. Of this total 26,300 calories (1,040,000 B.Th.U.) were converted into work, that is to say a little more than 10 per cent. of the heat contained in the regenerated steam and 7½ per cent. of the heat was not utilised.

* Due to the engine-driven pump being temporarily out of action.

† This appears to be an arithmetical error connected with a question in the translation.

## THE "WELLDECK" STEAM TRAP.

A NEAT and simple form of steam trap manufactured by Messrs. The Steam Fittings Company, Limited, of West Drayton, Middlesex, is illustrated below. This trap, which is known as the "Welldeck," has been on the market for some years, but our figure shows a new model which has recently been introduced and which has some important advantages compared with the older pattern. The trap is so simple that its mode of operation will almost be understood from the figure without explanation. The essential feature is the flat corrugated chamber which is hermetically sealed and contains a volatile spirit and its vapour. This, as will be seen, is attached to a valve below, and has a regulating screw at its upper side. To set the trap,



steam is allowed to pass through it for a few moments, until all water is expelled. The steam heats the volatile spirit and causes the chamber to open out, moving the valve downwards. With the chamber thus expanded the trap is then set by moving the regulating screw until the steam is just shut off. The regulating screw is then secured by its lock nut. The operation after this is obvious. The collection of any water cools the chamber so that it contracts and opens the valve, allowing the water to escape. As soon as steam begins to flow through, however, the valve closes again. When cold, there is a vacuum in the corrugated chamber, and the valve is wide open. It is stated that it is immaterial which end of the trap is used, as the inlet. It will be clear from the figure that the movement of the valve is positive and under the control of the chamber in either direction, while it is also self-aligning. It will also be seen that the corrugated chamber cannot be damaged by excessive pressure exerted on the regulating screw.

## NITROGEN PRODUCTS STATISTICS.

ALTHOUGH it remains doubtful whether or not the manufacture of synthetic nitrogen products will be able—or would be able—to thrive as a peace industry, independent of the support which ammunition works can give, the demand for fixed nitrogen, required chiefly for fertiliser purposes, is still growing at a faster rate than the potential output of the fixation plants. That might hardly be expected, considering that more new plants appear to have been put down than have been closed, and that large stocks of nitrates must have been released since the war. The complexity of the problems can be judged from the "Statistical Supplement to the Final Report of the Nitrogen Products Committee," which Dr. J. A. Harker, F.R.S., formerly Director of the Nitrogen Research Laboratory, of the Ministry of Munitions, has compiled. The pamphlet of 22 pages, issued by the Scientific and Industrial Research Department, is welcome and is instructive because it supplements the Final Report of the Nitrogen Products Committee, and because statistics concerning the war period and the post-war period have not hitherto been accessible. That some of the figures are uncertain estimates, is duly pointed out.

In the United Kingdom the pre-war average amount of nitrogen fertilisers (Chile nitrate and ammonium sulphate) applied to the soil was 24,000 tons; the figures for the years 1917–18–19 were 46,000, 47,000 and 58,000 tons, so that the consumption was, in 1919, nearly two and a half times as great as before the war. Similar increases are reported from other countries. The world's resources of nitrogen products were, in 1912, estimated at 4,000,000 English tons; of these, Chile supplied 57·5 per cent., by-product industries (ammonium sulphate) 38 per cent., and the nitrogen fixation industries 4·5 per cent. (3·1 per cent. being cyanamide and 1·4 per cent. nitrate of lime). The actual production of 1920 cannot yet be stated; but the total productive capacity had increased to

8,500,000 tons in round figures, of which Chile supplied 30·2 per cent., the by-products works 26·6 per cent., and the fixation plants 43·2 per cent., 20·9 per cent. being cyanamide, 2·5 per cent. nitrate of lime, and 19·8 per cent. synthetic ammonia. Thus, the synthetic ammonia factories, which had hardly any output in 1912, were able to supply one-fifth of the whole nitrogen products by 1920, and Chile was only called upon for less than a third of the total supply.

Yet the prices of Chile nitrate still dominate the financial position. For the years 1916 to 1918, the Liverpool price of nitrate was double that at Chilean ports, and although freights had fallen from 10*l.* to about 3*l.* per ton, the ton of nitrate still cost 22*l.* 14*s.* in January, 1921; the highest war price had been 27*l.* Before the war the biggest portion of Chile nitrate (nearly a third of the whole) had been shipped to Germany (which received in 1913, 830,000 tons); during the war, the United States left all the other countries far behind, receiving 1,674,000 tons of nitrate in 1918, but the mining of nitrate in Chile and the export from there declined very much (to half and a third the figures of 1917) in 1919, to rise again during 1920.

The importation of Chile nitrate into the United Kingdom increased during the earlier war years, including 1916, then fell off in 1917, recovered in 1918, but diminished once more very markedly in 1919 and 1920. After 1916, almost all that nitrate was converted into ammunition, and very little could be spared for fertilisation.

The saltpetre (potassium nitrate; the Chile nitrate, also sometimes called saltpetre, is a sodium salt) required by this country came mainly from Germany (7,500 tons out of a total of 12,000 tons) before the war. During the war, India increased its exports of saltpetre more than six times, but a strong decline set in again in 1919; the actual figures for India are not given, but it is stated that the saltpetre imports into the United Kingdom from British Possessions were, in the years 1914, 1916, 1918 and 1919, respectively 4,786, 21,957, 19,184, and 6,985 tons. The total production in the United Kingdom of nitric acid by various processes culminated in 1917 with 237,000 tons of 100 per cent. acid; the pre-war figure was 15,000 tons per year. The annual production of ammonium sulphate in the United Kingdom kept steadily at about 440,000 tons until 1917, when it dropped to 250,000; by 1919, it had risen to nearly 357,000 tons again. In the United States the ammonium sulphate output increased to 384,000 tons in 1919 (more than double the 1913 figure), and a still more marked increase, though on a smaller scale (to 91,000 tons), is reported from Japan. With respect to the ammonium sulphate statistics of the United Kingdom, Dr. Harker quotes the Chief Alkali Inspector's reports, to which we should refer our readers*; it should be noticed, however, that these figures are not official returns in a strict sense, for the Chief Inspector expresses his indebtedness to the courtesy of the manufacturers in giving these statistics, as we have pointed out on other occasions.

From some countries reliable data could not be obtained, and as regards synthetic ammonia in Germany Dr. Harker offers his figures as approximate estimates. According to these, the production of synthetic ammonia had risen from 25 metric tons per day in 1914, to 620 tons in 1918, and to 1,050 tons in 1920; the last figure would correspond to an annual output of 1,500,000 metric tons of ammonium sulphate. In this connection remarks have been made in German technical journals as to "flattering estimates of the productive capacity of our synthetic works in the foreign Press."

The lime nitrate (nitrolim) production of Norway at first decreased and subsequently increased during the war, the decrease being balanced by the manufacture of other nitrogen products, ammonium nitrate, sodium nitrate, calcium cyanamide, and, finally, also nitric acid at Notodden and Rjukan; the total Norwegian production in this field was in 1920 about double that of 1914. The cyanamide manufacture has by no means been superseded by that of other nitrogen products; the world's production of cyanamide for 1912 was 126,500 metric tons; that for 1918 was estimated at 609,000 tons. Nine new cyanamide works have been erected in France. The United States cyanamide plant erected in Alabama, in 1918, is credited with an annual capacity of 200,000 long tons, and the German output may equal that of all the other countries together. Plants for oxidising ammonia in the preparation of nitric acid or ammonium nitrate, which hardly existed before the war outside Germany and Belgium, have since 1914 been built in various countries; Dr. Harker only gives information about two German and two American works.

Summing up, we find that nitrogen was, in 1920, actually being fixed in 50 works, of which 12 oxidised atmospheric nitrogen by the electric arc, 35 prepared cyanamide, and 3 synthetic ammonia; the respective capacities of these three classes of works, reckoned in metric tons of nitrogen (not of ammonium sulphate or other salts), per year, are 38,000, 325,000, and 308,000, a total of 671,300 metric tons of fixed nitrogen. The cyanamide estimate is probably too low in Dr. Harker's opinion, as he allows only 120,000 tons for Germany's share. The installed power of the works of the first two classes of works (not including the synthetic ammonia factories) represented a little over a million kilowatts in 1920, this figure being three times as large as the pre-war figure.

As regards British works for the fixation of nitrogen, the synthetic ammonia plant, commenced by the Ministry of Munitions early in 1918, but very little advanced by the time of the Armistice, has recently been taken over by Messrs. Brunner, Mond and Company, and has been re-designed to manufacture fertilisers rather than the ammonium nitrate first intended. The subsidiary company, which the firm mentioned has promoted, styled Synthetic Ammonia and Nitrates, Limited, is at present concentrating upon an initial plant for 25 tons of ammonia per day, or 7,000 tons of nitrogen per year; but the works are laid out so as to admit of a ready extension of this nucleus to four and even twelve times that capacity. The original Government site of 260 acres, has been enlarged to 1,000 acres, and two ship berths have been acquired on the Tees. An oxidation plant for 12,000 tons of nitric acid per year, and plants for other by-products are also projected.

A British company, the Cumberland Coal Power and Chemicals, Limited, has also been formed to erect works for the operation of the Claude synthetic ammonia process; a full-size commercial unit, working at a pressure of 1,000 atmospheres, and producing 5 tons of ammonia per day, is now running, it is stated, satisfactorily in France. The British Cyanides Company, of Birmingham, is fixing nitrogen by means of barium in fuel-heated furnaces; these large-scale experiments are described as partially successful. The works of the Nitrogen Products Company, at Dagenham, in which cyanamide was, during the war, converted into ammonium nitrate by the Ostwald process, have been closed. The demand for explosives and for ammunition is, of course, not likely to cease, in view of which fact efficient synthetic processes will always be required.

*See Alkali Works in 1920, ENGINEERING, July 29, page 190, *ante*.

## THE JUNIOR INSTITUTION OF ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—As a member of the "Juniors" for more than 25 years, and as a past chairman of that excellent little Institution, I should like to express my thanks for your leading article on "The Younger Men," which I am glad to see has been endorsed by so many of our oldest members. The shrinkage of the word "Junior" on the cover of our monthly journal, and the elimination from our official letter headings of the phrase "founded for the junior members of the profession" both give evidence of a foolish desire to pretend that the Institution is something which it is not, and which it was never intended to be. The new scale rule which the Council are asking the Board of Trade to sanction, is the last straw, for it would debar from the status of membership the very men for whom the Institution was founded.

We have now a large number of members who, as far as years are concerned, can no longer be called young. Whether they have grown up with the Institution, or whether they have joined it later, the great majority of them are only in it because they wish to give any help they can to the young men who are now travelling the road over which they themselves have already passed. This is the spirit we want, and which we mean to keep. I am certain that the older members do not want to be railed off from the younger and kept in a separate enclosure consistent with their "dignity." They accept whole-heartedly the motto of "for Juniors by Juniors," and are not out for what they can get from the Institution, but for what they can do for it.

In my opinion the seeds of the present trouble were sown when first the classification of members into different grades was attempted. For a long time they lay dormant, but now have blossomed into an evil flower. Those who value the old traditions upon which the success and usefulness of the Institution has been founded, and which have earned for it the sympathy and practical assistance of so many of the leading engineers in the country, realise that the time has come when we must reassert our principles in an unmistakable manner and once and for all make it clear that we will have no tampering with our ancient landmarks. It is therefore my intention to move a resolution at the next annual general meeting providing that there shall be one class of membership only, but that annual subscriptions shall be graded in three steps according to the age of the member.

I hope and believe that this resolution will receive such support as will reassure engineers outside as well as inside the Institution that we are, and are determined to continue "for the junior members of the profession." My fellow members will no doubt take care, as far as possible, that the members elected on the next council shall only be such men as will truly maintain our old policy and traditions.

I am, yours faithfully,

7 Victoria-street, S.W. 1. F. D. NAPIER.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—There is no great hurry on the part of either home or foreign buyers to turn inquiries for steel and steel products into actual orders. All sections of the steel and engineering trades are suffering from the same malady. Hope of a revival is gradually gaining strength, but with the advent of each successive week, improvement seems to be as far off as it was before. Sufficient time has not elapsed to allow benefit to accrue from wages reductions in the manufacturing branches. Stocks have first to be cleared, mostly at a considerable sacrifice, before the effect of lower production costs is felt. Rolling mills and forges have sufficient orders of the hand-to-mouth variety to employ reduced staffs slightly more than one-third of the normal working time. Steel foundries are scarcely any better off owing to the sluggish nature of new business in heavy engineering, but hope to benefit considerably from home and foreign naval programmes. A sure indication that progress, though slow, is being made, is found in the fact that Sheffield's total of unemployed, officially recorded, has been reduced from over 60,000 at the termination of the coal strike to 40,000 to-day. The latter figure represents about four times the amount of dislocation experienced in normal times. Continental competition in raw and semi-finished materials appears to be on the wane. Belgian makers seem to have carried their policy of underquoting rather too far, and to be less ready to undertake prompt deliveries at cheap rates. The latest information received locally further shows that German producers are in danger of over-taxing production, and are seeking an extension of delivery dates. Now that prices have been reduced, steelmakers are calling for slightly larger deliveries of British iron. West Coast traders are offering mixed Bessemer numbers 10*s.* below last week's quotation, the current figure standing at 8*l.* 5*s.* delivered. The slump in the demand for alloys has produced a wholesale collapse of prices. Merchants are glad to dispose of stocks at prices in some cases below the 1914 level. There is an abundance of iron and steel scrap, but very few buyers. The engineering trades are not taking sufficient machine-made files, saws, and other small tools to keep works in constant production. Big stocks have accumulated at drop stamping plants.

*South Yorkshire Coal Trade.*—County coalowners' associations are chary of committing themselves to promises of price reductions. In reply to a communication sent by Sheffield and district manufacturers, the Yorkshire Coalowners' Association points out that its members are not in a position to make reductions at a greater rate than the economic situation demands. The Midland County Colliery Owners' Association responds that until wages and costs of material can be materially decreased, there seems little prospect of a substantial reduction. Despite the indefinite nature of this information, South Yorkshire steelmakers and engineering masters are convinced that the early future will witness a substantial adjustment in the price of manufacturing fuel. The widespread refusal to place contracts at current rates has not improved the position at pits. Stocks under load are increasing, sidings are blocked, and production is necessarily limited to less than half the normal number of working shifts. Competition for new business being exceptionally keen, a number of orders have been booked at as much as 5*s.* below official quotations. Locally the market is feeling the strain, and prices at the pithead are lower to the extent of 1*s.* in the case of best steam hards to 2*s.* 6*d.* to 3*s.* in the case of smalls and slacks. Railways and gas companies have made big strides in the repletion of stocks, and are not ordering with anything like their former freedom. The order books of household merchants present a thin appearance. "A strike of buyers" is the description applied to the situation by an official of the Sheffield Coal Exchange. Revised quotations: Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire brights, 37*s.* to 38*s.*; Derbyshire house coal, 35*s.* to 37*s.*; Derbyshire best large nuts, 34*s.* to 35*s.*; Derbyshire small nuts, 33*s.* to 34*s.*; Yorkshire hards, 34*s.* to 35*s.*; Derbyshire hards, 33*s.* to 34*s.*; rough slacks, 19*s.* to 20*s.*; nutty slacks, 18*s.* to 19*s.*; smalls, 12*s.* to 13*s.*

MIDDLESBROUGH PIG IRON SHIPMENTS.—The statement for July recently issued by Messrs. William Jacks and Co., 5, East India Avenue, E.C., shows that the shipments of pig iron from Middlesbrough, including Skinningrove, during that month were 2,035 tons coastwise and 3,205 tons foreign, a total of 5,240 tons, as compared with 43,630 tons in July, 1920, and 15,410 tons in July, 1919.

MOTOR CARS ON MOUNTAIN ROADS.—We have received from Messrs. Rolls Royce, Limited, of Conduit-street, London, W.1, an interesting account of a tour of 3,150 miles recently accomplished by a Rolls Royce touring car over the highest mountain roads and passes in Europe. The car with four passengers and luggage weighed over 2¼ tons and traversed on its journey 53 passes, with an aggregate altitude of 293,296 ft. The itinerary included the highest road in Europe, namely, the Stelvio (9,041 ft.) and the Col du Parpaillon (8,671 ft.). The former of these, only 8 ft. wide, with 15 per cent. gradients, was in a terrible state of disrepair, gangs of labourers having to be employed on four occasions to clear away debris in order that the car might proceed. In spite of the severity and number of the descents, the brakes were only once adjusted on the journey, and the car finished the trip in perfect condition, as it subsequently attained a speed of 77 miles per hour with full load, on one of the straight open roads in France.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*The Cleveland Iron Trade.*—Little new is ascertainable so far as Cleveland pig-iron is concerned. Scarcity of No. 3 G.M.B. continues pronounced, and any small parcels that come on the market are quickly snapped up at 135*s.* Only two firms are producing No. 3 for the market, and what stocks there are of this quality are sold. Other grades of Cleveland pig are quite plentiful, No. 4 foundry is offered freely at 125*s.*; No. 4 forge and mottled are difficult to dispose of at 117*s.* 6*d.*; and white iron is almost unsaleable at makers' agreed on minimum of 115*s.* Producers have large stocks of these inferior grades.

*Hematite.*—There are now six furnaces turning out East Coast hematite with the result that more of this commodity is on the market and prices have been reduced. Nos. 1, 2 and 3 are now obtainable on both home and export account at 140*s.*; and No. 1 is put at 142*s.* 6*d.* Home quotations are thus 20*s.* below rates that have ruled for some time past.

*Blast Furnaces in Operation.*—Of the 72 blast furnaces erected in this area only 14 are in operation, six of which are running on hematite iron, four on Cleveland pig, and the remainder on basic. Three more furnaces, however, may be re-started in the near future—two on Cleveland foundry iron and one on basic.

*Foreign Ore.*—No effort to recommence business in foreign ore is noticeable, sellers realising the futility of such a step with consumers overwhelmed with stocks and compelled to refuse acceptance of deliveries long overdue on old contracts.

*Coke.*—Further marked downward tendency in coke is gratifying. Sellers still name 35*s.* delivered as the price of Durham blastfurnace description, but local consumers consider the maximum figure should be 30*s.* and confidently look for that price ruling soon.

*Manufactured Iron and Steel.*—Extreme quietness characterises manufactured iron and steel, and a further cut in prices seems imminent. Common iron bars are 16*l.*; marked bars, 20*l.*; steel billets, 10*l.* 10*s.* to 11*l.*; steel boiler plates, 19*l.*; steel ship, bridge and tank plates, 14*l.*; steel angles and joists, 13*l.* 10*s.*; tees, 14*l.*; rounds and squares, 13*l.*; flats, 14*l.*; heavy steel rails, 14*l.*; fish plates and sleepers, 19*l.*; black sheets, 17*l.*; and corrugated galvanised sheets, 20*l.* 10*s.*

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel Trade.*—There has been no opening out in the Scottish steel trade yet, and the latest reduction in prices of home steel has not brought out much in the way of fresh business. Buyers are very slow in committing themselves at present and continue to hold off as long as possible, but all the same, there are signs of some improvement. With the foreign material offered considerably cheaper than that of the home makers, there is a strong inclination to send orders out of the country, because of the saving on large contracts, and if the unemployment here is to be reduced the price of fuel, &c., must be brought down in the near future. Reductions have certainly been made of late, but not of sufficient proportions to meet the situation. Taken all over, however, the outlook is perhaps a little better than it has been for some months.

*Malleable Iron Trade.*—The West of Scotland malleable-iron trade cannot be said to be any better, and employment at the majority of the works is largely of a hand-to-mouth character. Orders are not being received in volume anything like equal to the possible output of the mills, and inquiries are not too encouraging either. Prices show no change, although buyers anticipate a fall before long, and it is generally acknowledged that such will be necessary if the Continental competition is to be met.

*Scottish Pig-Iron Trade.*—There is still very little change in the state of the pig-iron trade in Scotland, but the relighting of some of the furnaces has improved the position as regards foundry sorts at any rate. Fuel, one of the main factors in the case, has been gradually easing in price, and there are prospects of more furnaces being put into blast very soon. The general home demand is not much better, and export business is not likely to improve until financial conditions abroad get on to a more satisfactory footing. The Continental iron continues to come in here at a very low price and is a big inducement to buyers.

*Scottish Shipbuilding.*—The shipbuilding returns for the past month are notable from the fact that no new vessels were launched in any of the areas outside the Clyde where the output was 34 vessels of 34,616 tons, which is about the average monthly tonnage this year. The total figures for the year to date are now 165 vessels of 299,864 tons, which, on the whole, is fairly good, considering the unsettled state of labour during the past few months. For the corresponding period of last year, the output was 142 vessels of 440,174 tons, and for the same period of 1912 the total was 189 vessels of 417,551 tons, which two rank as the highest outputs for the eight months under review. The demand for new vessels is still very poor, but with the recent reductions in wages, as well as fuel and steel material, the costs at the yards are not now so heavy, and the prices named for new tonnage show a decline. These prices are still too high for shipowners yet, and until they fall much further little in the way of fresh contracts are likely. Things are pointing in the right direction, however, and the outlook is much better. The return of the shipyard joiners to work, and in consequence the restarting of a number of other workmen, has put more activity into the industry, and in several yards which were only working a part of the week, full time now prevails.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Coal Trade.*—While prices generally show no material alteration to those ruling a week ago, the tone of the market is certainly steadier, and sellers are now firmly resisting the bear tactics of buyers and refusing to cut quotations further. In fact, in some cases the tendency is firmer. The market, however, is "patchy," with values dependent on the individual circumstances of collieries. Some are comfortably placed, having booked up a number of orders, but the majority still find difficulty in disposing of outputs, owing to the continued restricted needs of inland customers, and the fact that the railways are only taking very limited quantities because of the large stocks of American coal on hand. Gradually the large works are being restarted, and this will undoubtedly have a steadying influence on the coal trade generally as any improvement in the home demand has an indirect influence on the export trade. Inquiries both from at home and abroad are more numerous, and it is believed that buyers are now ready to do business, though in practically all cases they are trying to secure supplies at below current values. Inquiries are circulating for delivery of substantial quantities over the whole of next year, and while collieries generally refuse to commit themselves, they are asking consumers to give them specific information as to what they require before giving a definite price. At the moment, best and second-class Admiralty large coal is round 32*s.* 6*d.*, with best Monmouthshire large at 30*s.*; best steam smalls, 19*s.*; with ordinary smalls down to 14*s.* It is significant that foreign cargo exports in the past week totalled no less than 395,000 tons, which is the highest quantity despatched in any week of the year. This total was only exceeded in four weeks of the previous year, but a considerable amount of leeway has to be made up before the pre-war volume of trade is reached, last week's shipments representing only about two-thirds of the 1913 weekly average of 600,000 tons. Exports to France and Portugal at 134,000 and 27,000 tons respectively last week established a record for the year as also did the 78,000 tons sent to "other countries," which included two large cargoes to Russia for the first time for some years past and a number of shipments to Far Eastern ports.

*Iron and Steel.*—Though the demand remains curtailed prices on the whole are steady, and with coal prices down, makers are disposed to re-start mills, though it is openly declared that unless orders are forthcoming the works cannot be kept going for long. The undercurrent of feeling is, however, optimistic, especially in respect to the far distant markets.

TECHNICAL COLLEGE, BRADFORD.—The calendar for the session 1921–22 gives details of the full-time (day) and part-time (mainly evening) courses in the departments of textile industries, chemistry, dyeing, mechanical, civil and electrical engineering, and biology of the College. The full-time courses extend over three or four years, and the part-time courses involve attendance on three evenings a week during three or five sessions. The courses have been specially designed to meet the needs of students wishing to receive a technological training which will enable them to occupy higher positions in industry, the part-time courses being particularly intended to meet those of students who are engaged in industry during the greater part of their time. The equipment of the College is extensive and includes a complete plant for the washing, carding, combing, spinning, weaving, dyeing and finishing of textiles. A special feature of the equipment is the power-house, which has been arranged for demonstration purposes, and which supplies the whole of the power and light required. Special facilities are also provided for microphotographic work, for automobile engineering and for heat treatment.

THE SIR JOHN CASS TECHNICAL INSTITUTE.—The new session at this Institute, which is situated in Jewry-street, Aldgate, E.C. 3, will commence on Monday, September 26, and students will be enrolled during the previous week commencing Monday, September 19, between 7 p.m. and 9 p.m. The courses of instruction are especially directed to the technical training of those engaged in the chemical, metallurgical and electrical industries and in trades associated therewith. Full facilities are provided in the well-equipped laboratories of the Institute for special investigations and research work. The instruction in experimental science also provides systematic courses for the examinations of London University and of the Institutes of Physics and Chemistry. Special courses of higher technological instruction form a distinctive feature of the work of the Institute. For the forthcoming session these include courses on the fermentation industries, glass technology, colloids, metallography and pyrometry, heat treatment and mechanical testing of metals and alloys. An important development for the new session is the establishment of courses of instruction in petroleum technology. These have been arranged in consultation with representatives of the chief oil companies and have been designed to meet the requirements of those engaged in, or associated with, the practical and scientific control of the petroleum industry.

## NOTICES OF MEETINGS.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, September 7, at 2.30 p.m., in the Natural Philosophy Department of the University, Drummond-street, Edinburgh. The following papers will be read:—1. "The Functions of a Scientific Society with Special Reference to Meteorology," by R. H. Hooker, M.A., President. 2. "Meteorology in Medicine," by Angus Macdonald, O.B.E., M.D. 3. "Some Notes on Meteorology in War Time," by C. J. P. Cave, M.A., J.P. 4. "The Diurnal Variation of Pressure at Eskdalemuir, 1911–20," by Dr. A. Crichton Mitchell, F.R.S.E. 5. "The Natural Tendency Towards Symmetry of Motion and Its Application as a Principle in Meteorology," by Dr. S. Fujiwhara (of the Central Meteorological Observatory, Tokyo).

IRON AND STEEL INSTITUTE.—Monday, September 5, to Saturday, September 10, Autumn Meeting at the headquarters of the Comité des Forges de France, 7, Rue de Madrid, Paris, commencing on Monday at 10.30 a.m. and on Tuesday at 10 a.m. The following will be submitted to the meeting on Monday and Tuesday: (1) N. T. Belaiew, C.B., "Damascene Steel"; (2) E. L. Dupuy, "An Experimental Investigation of the Mechanical Properties of Steels at High Temperatures"; (3) L. Guillet, "The Situation of the French Metallurgical Industry in the North and in the East of France: its destruction and reconstruction"; (4) K. Honda, "Does the Critical Point Depend on the Strength of the Magnetising Field?"; (5) A. Portevin, "On Constituents Found in Tungsten and Molybdenum Steels"; (6) A. Portevin and V. Bernard, "A Contribution to the Study of Coalescence"; (7) A. Portevin and P. Chevenard, "On the Characteristic Curves of the Heat Treatment of Steels"; (8) P. Nicou, "Iron Ore Deposits of Eastern and Western France"; (9) E. Schneider, "An Investigation of various Forging Operations carried out under Hydraulic Presses," Part II; (10) Capt. H. W. B. Swabey, C.B., and R. Genders, M.B.E., "Manufacture of Shells in Canada during the War, 1914–18." On Monday, September 5, a reception will be given by the Comité des Forges, at 9.30 p.m., at the Hotel de l'Union Interalliée, 33, Faubourg St. Honoré. Members participating in the excursions, Group I, to Lorraine, and Group II, to Creusot and St. Chamand, will leave Paris on Tuesday afternoon, September 5; those in Group III, to Normandy, will leave Paris on Wednesday morning, September 7. The members taking part in all the above excursions will return to Paris in the night of Friday, September 9.

AIRSHIP DISASTER MEMORIAL SERVICE.—The Air Ministry has announced that it has been decided to hold a Memorial Service for the American and British officers and men lost in the airship R. 38. The service will be held in Westminster Abbey on Wednesday, the 7th inst., at 12.30 p.m., and will be attended by representatives of His Majesty the King, Chief of the Royal Air Force, of the Air Council, and of the British Navy, Army and Air Force, as well as of the American Forces. The detail arrangements are not yet completed, but it is hoped that a portion of the Abbey will be open for the admission of the general public.

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION.—From the quarterly report of this association just issued it appears that a number of interesting investigations are now being undertaken by the above association which has the support of the Department for Scientific and Industrial Research, the Institution of Electrical Engineers and the British Electrical and Allied Manufacturers' Association. Amongst the most important of these is an inquiry into the phenomena of switching and arcing, for which with the assistance of the Newcastle Electric Supply Company large scale tests have been arranged. Another important research is to deal with the whole question of the manufacture in this country of insulating materials with a synthetic resin base.

THE INSTITUTION OF MINING ENGINEERS.—The thirty-second annual meeting of the Institution of Mining Engineers, will be held on Wednesday to Friday, September 14 to 16, commencing in the Town Hall, Stoke-on-Trent, on the 14th, at 11 a.m. At the opening meeting, the members will be welcomed by Mayor, Alderman Sampson-Walker, and after business, the President will deliver an address. The following papers will also be read and discussed:—(1) The Adsorption or Solubility of Methane and Other Gases in Coal, Charcoal and Other Substances, by J. Ivon Graham, M.Sc; (2) Suggestions for the Standardisation of Geological Sections of Strata Proved in Boreholes, Shafts, &c., by H. Roscoe, O.B.E.; (3) Coal Mining by Steam Shovel in Alberta, Canada, by George Sheppard. Papers which have already appeared in the Journal will also be discussed. The meeting will be continued in the afternoon, and at 7 p.m. the annual dinner will be held in the Town Hall. On Thursday, alternative excursions have been arranged, including visits to Whitfield Colliery and Messrs. Kerr, Stuart and Company's California Works, and Deep Pit, and the Etruria Works of The Shelton Iron, Steel and Coal Company. On Thursday evening there will be a reception at the Town Hall, at the invitation of the North Staffordshire Colliery Owners' Association. On Friday, a tour round the North Staffordshire Coalfield has been arranged. Members may obtain further particulars from the Secretary, Mr. A. B. Atkinson, 40, High-street, Newcastle, Staffordshire, to whom applications for tickets, &c., must be made before September 6.

# ENGINE AND BOILERS FOR CARGO STEAMER "P.L.M. 20."

CONSTRUCTED BY THE NORTH-EASTERN MARINE ENGINEERING COMPANY, LIMITED, ENGINEERS, WALLSEND-ON-TYNE.

(*For Description, see Page* 339.)

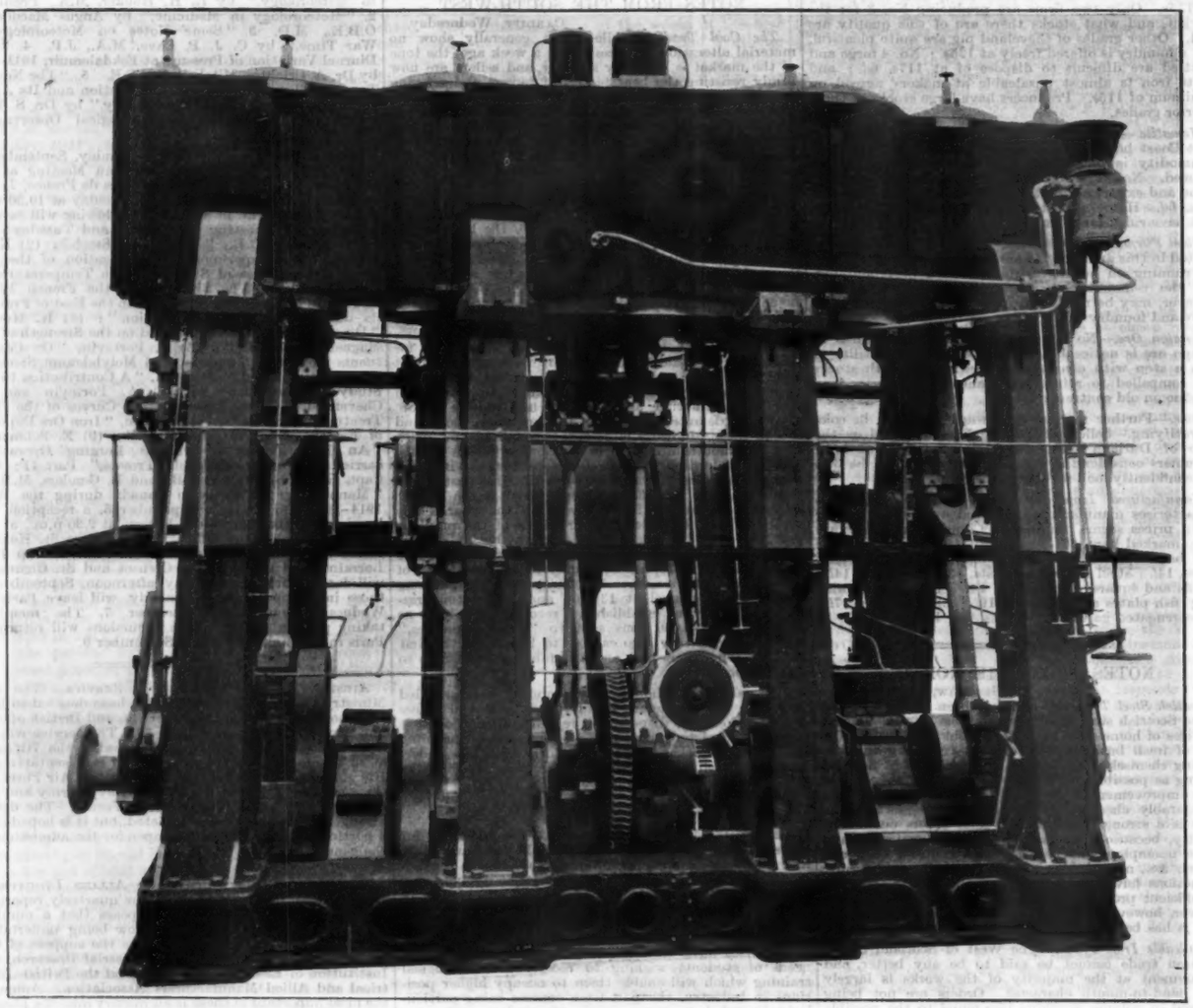


Fig. 6. Quadruple-Expansion Engine.

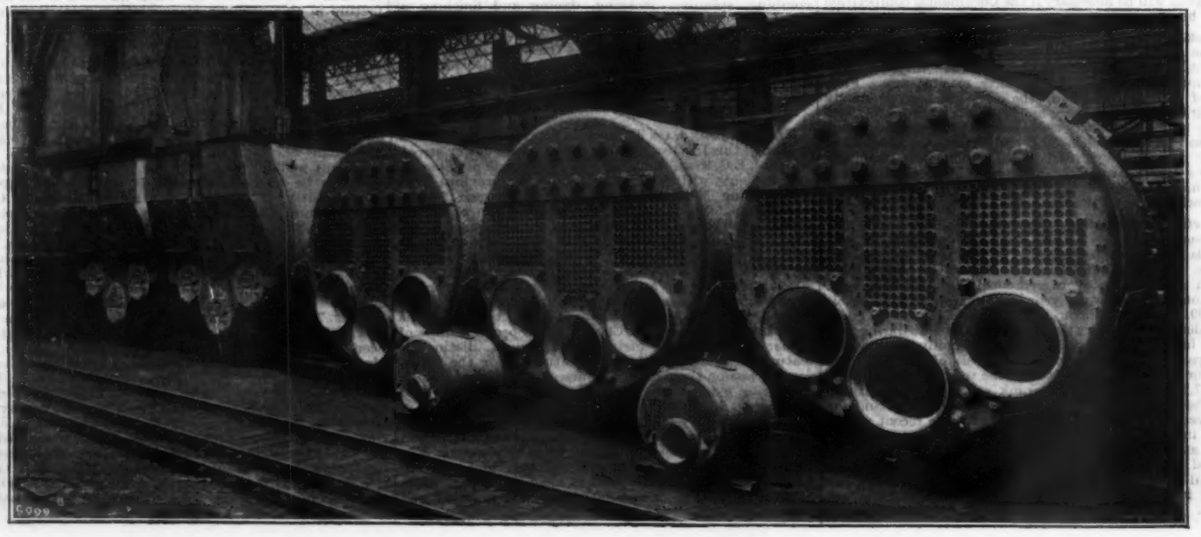


Fig. 7. Boilers in the Maker's Shops.

# THE WORKS OF MESSRS. EDGAR ALLEN AND CO., LIMITED, SHEFFIELD.

(For Description, see Page 335.)

(To face page 336.)

FIG. 20. PATTERN MAKING SHOP.

FIG. 21. VIEW IN FOUNDRIES.

FIG. 22. VIEW IN FETTLING SHOP.

FIG. 23. MACHINE SHOP, FOUNDRY DEPARTMENT.

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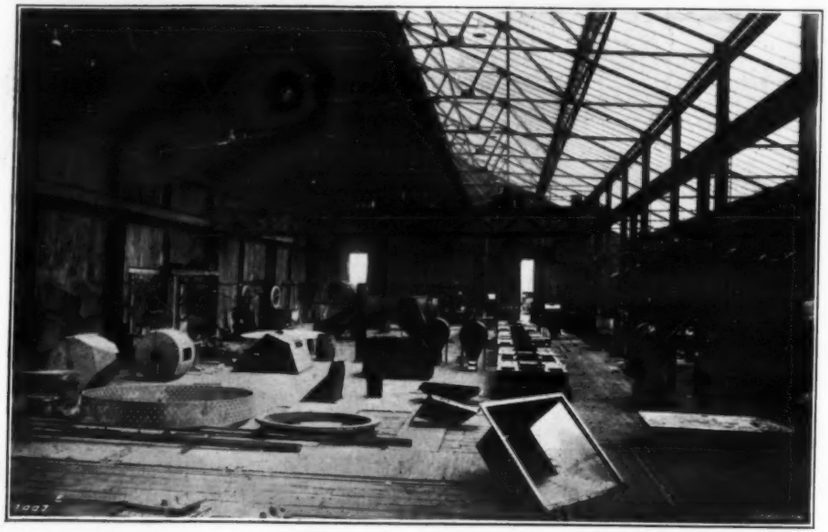


FIG. 24. LIGHT PLATING SHOP.

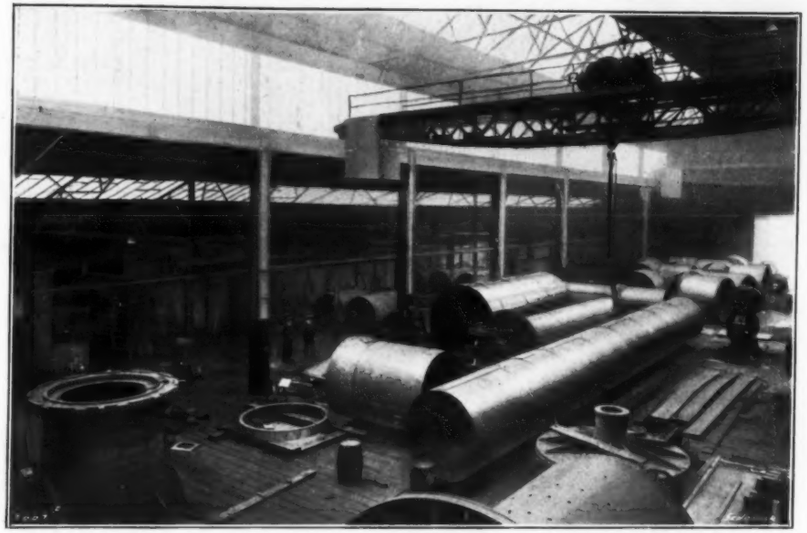


FIG. 25. HEAVY PLATING SHOP.

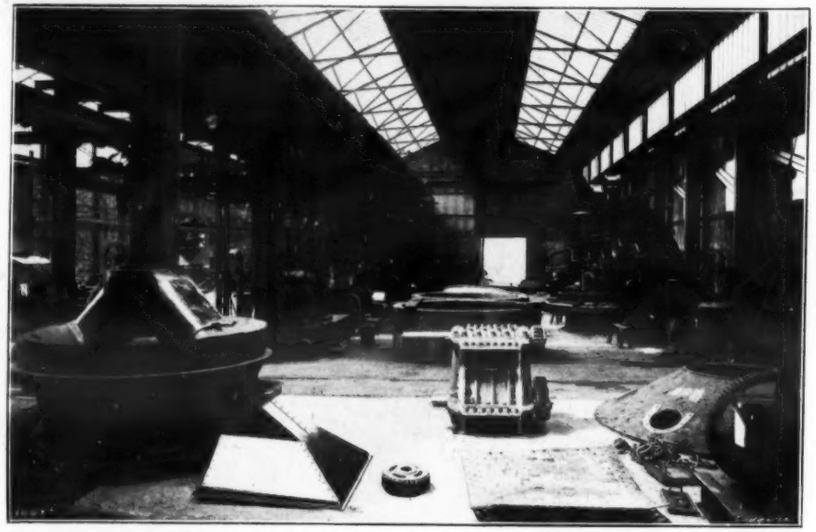


FIG. 26. MACHINE SHOP.

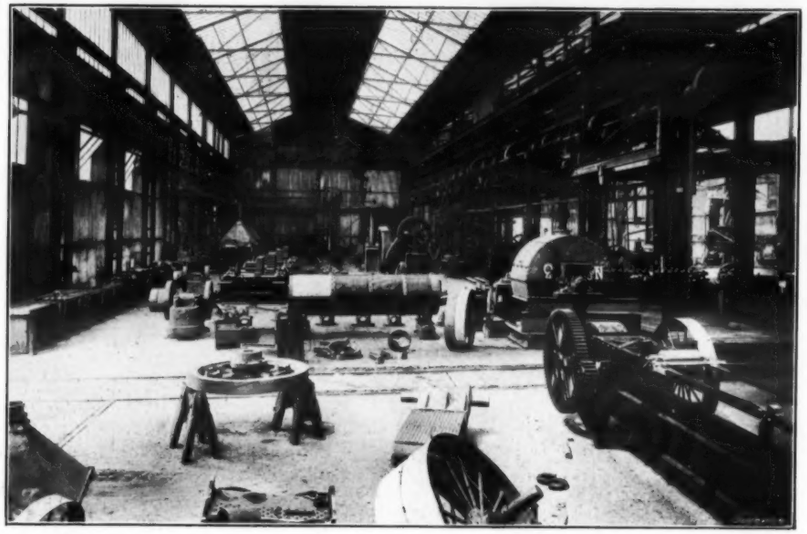


FIG. 27. ERECTING SHOP.

# THE HYDE WELDING PROCESS.

(*For Description, see Page* 338.)

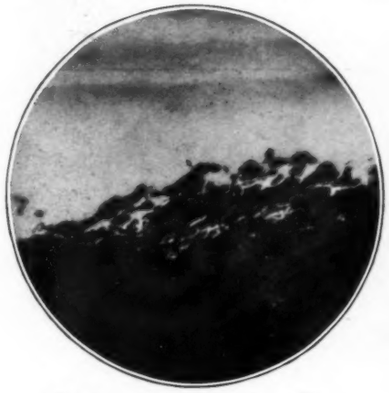


FIG. 1. MAGNIFICATION × 200.

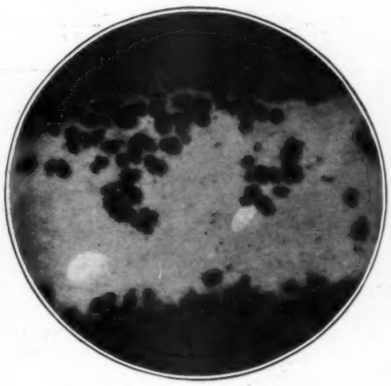


FIG. 2. MAGNIFICATION × 270.

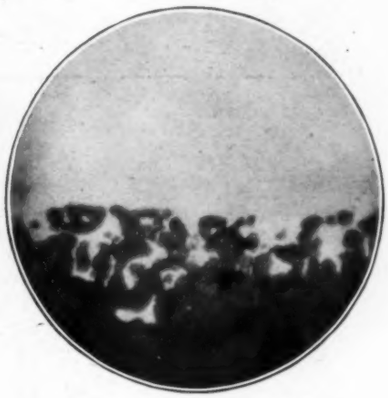


FIG. 3. MAGNIFICATION × 270.

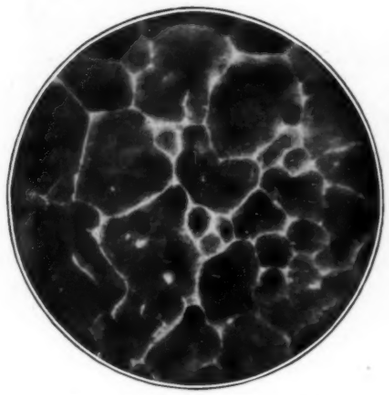


FIG. 4. MAGNIFICATION × 240.

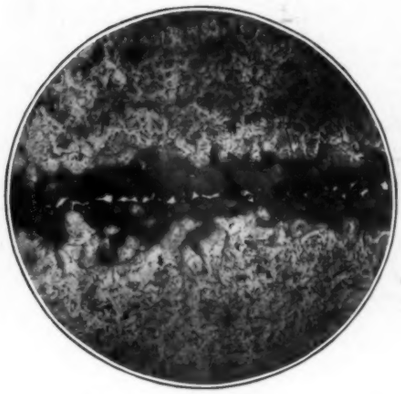
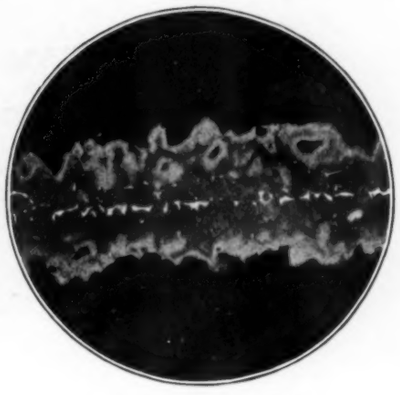


FIG. 5. MAGNIFICATION × 36.



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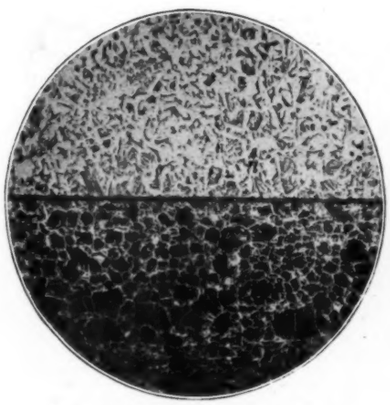

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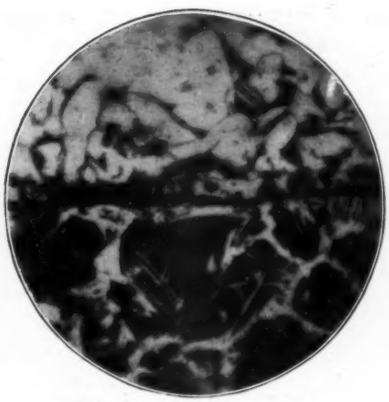

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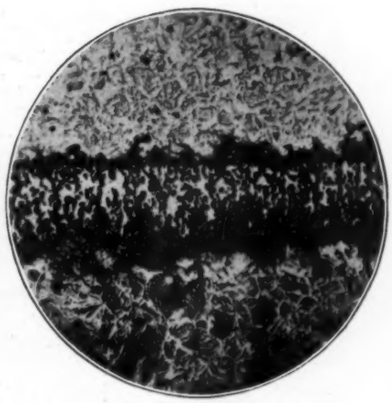

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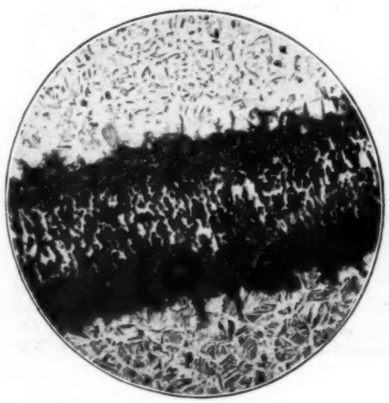
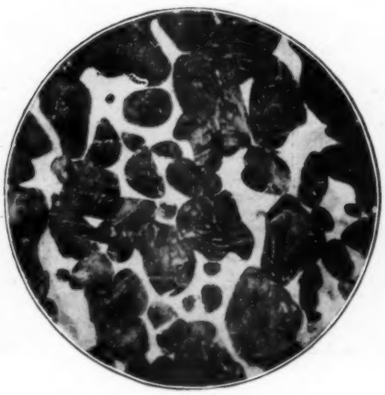


FIG. 10. MAGNIFICATION × 36.



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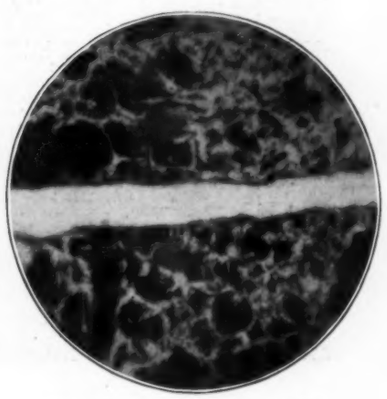

FIG. 12. MAGNIFICATION × 36.

(*To face page* 338).

# CANTILEVER SELF-TRIMMING CARGO STEAMER "P.L.M. 20."

CONSTRUCTED BY SIR RAYLTON DIXON AND CO., LIMITED, SHIPBUILDERS, MIDDLESBROUGH-ON-TEES.

(*For Description, see Page* 339.)

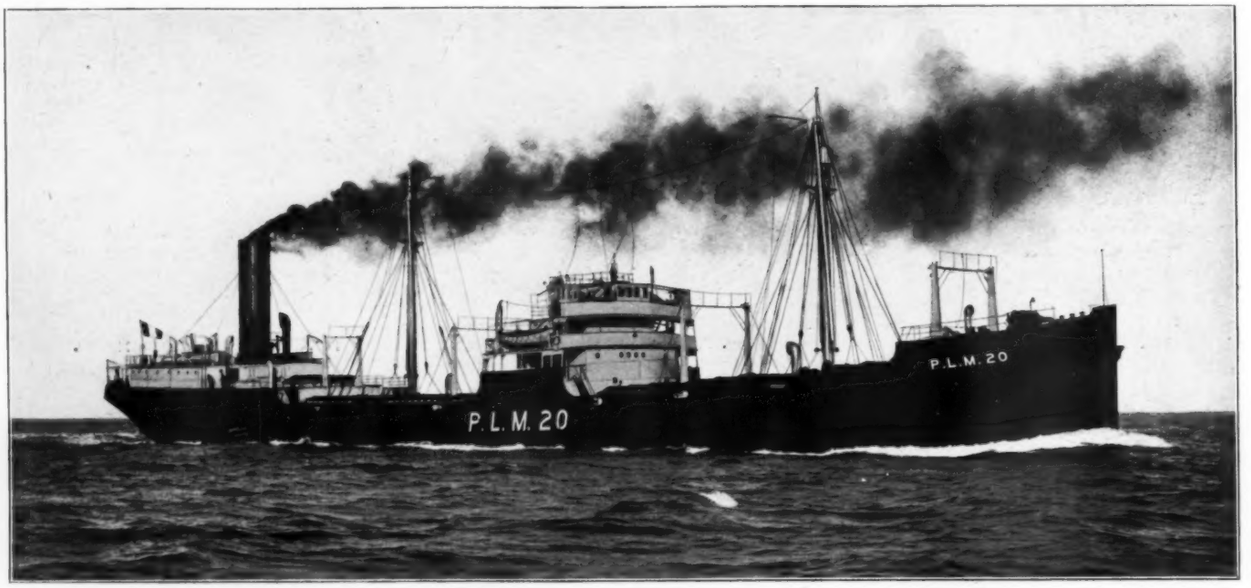


FIG. 1. VIEW OF THE VESSEL ON HER TRIALS.

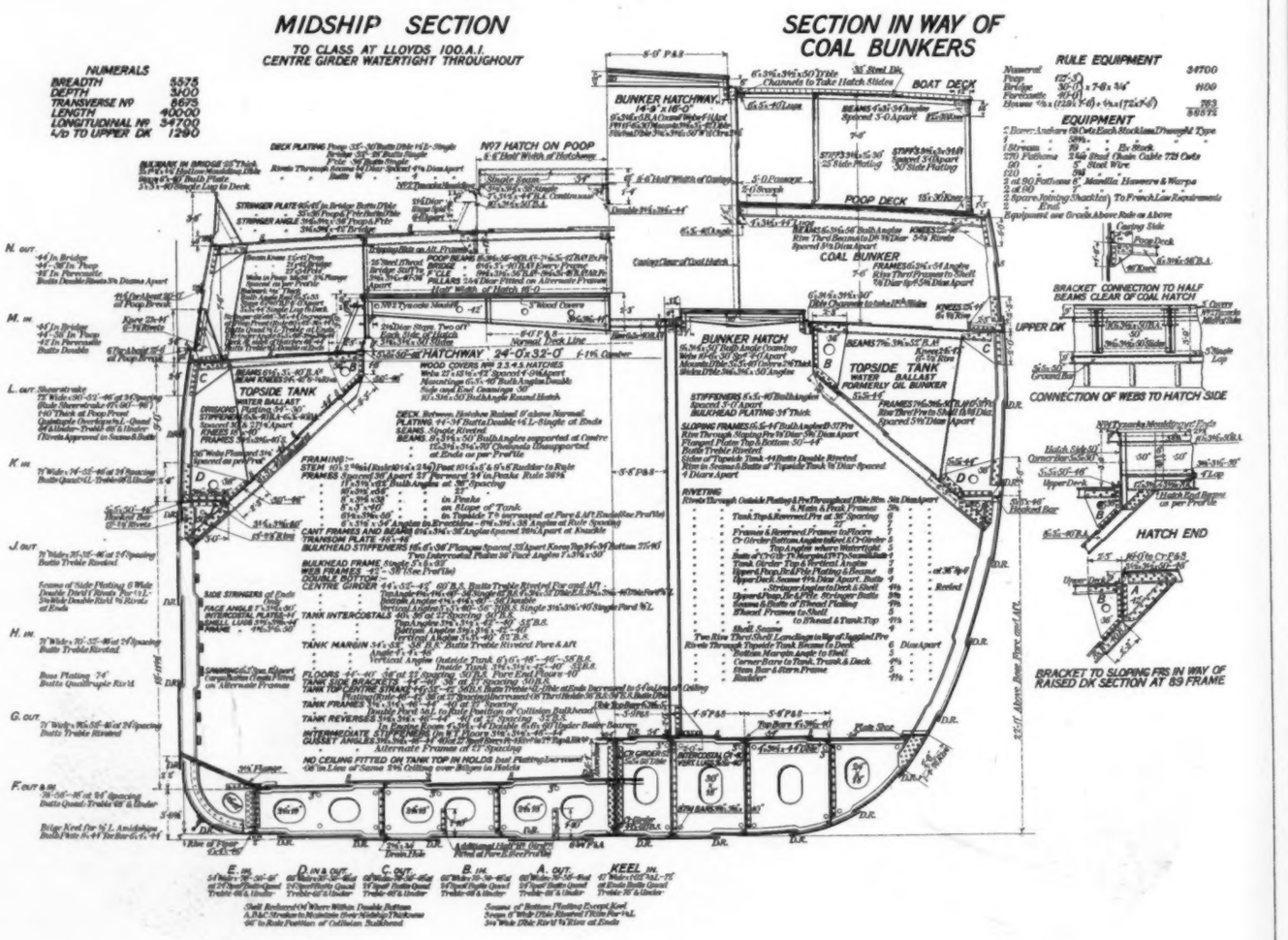


FIG. 2.

(*To face page* 339.)

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## ADVERTISEMENT RATES.

**Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.**

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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**Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C.2.**

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8398 GERRARD.


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## NOTICES OF MEETINGS.

**Notices of Meetings to take place during the present and next week will be found on page 347.**


# ENGINEERING.

*FRIDAY, SEPTEMBER 2, 1921.*


## THE REPORTS OF THE INDIAN BRIDGE COMMITTEE.

THERE are quite plausible grounds for maintaining that bridge design as practised to-day has become one of the least scientific branches of engineering. In other fields hypothesis and calculation are constantly checked by comparison with experience, but to an increasing degree, during recent decades, structural engineers seem inclined to lean more and more on formulas and on *a priori* assumptions, and less and less on the results of observation. Whether or no Talleyrand was justified in defining language as something given us with which to conceal thought, few will dispute that algebra and mathematical analysis were developed with the intent to economise mental effort. By certain almost mechanical operations we are thus able with a minimum of strain to determine the logical consequences deducible from certain premises; but, unfortunately, too many bridge engineers seem inclined to regard formulas not as instruments for saving thought, but as a substitute therefor. A check to this tendency followed the fall of the first Quebec Bridge, concerning which it may be recalled that when details were still lacking one bridge engineer advanced the opinion that the catastrophe was to be attributed to the existence of certain secondary or indeterminate stresses at the junctions of some of the main members. Such an opinion could only have been proffered by one who had failed to study the records of experience. Disastrous bridge failures have occurred in all countries; but we have yet to learn of a single instance in which the collapse arose from indeterminate or secondary stresses. The hypothesis in question illustrates well the propensity against which we protest, viz., that of regarding the calculated intensity of a stress as being in all cases a measure of the factor of safety. A bridge member overstrained by (non-alternating) secondary stresses is in fact able to pass on its surplus to such of its neighbours as may not be taking their fair share of the load.

There is, perhaps, one apology to be made for the reluctance of bridge engineers to base their designs on actual practical experience, viz., that the collapse of a bridge may be an exceedingly serious affair, a notable instance being the Tay Bridge disaster, and so long as a designer holds by accepted formulas his defensive position, should a failure occur, is an exceedingly strong one. In this connection it would be interesting to know how many English or American bridge engineers would have shown the courage displayed by M. Rabut, who lengthened by 8 metres the 40 metres span of the Rue Legendre road bridge over the Western of France Railway without adding any material to the top or bottom flanges. This was done, although calculations made in the ordinary way indicated that these flanges were already fully loaded, but measurement by extensometers proved that the actual stress was very much less than the computed stress, owing to the fact that the roadway constituted a very substantial reinforcement to the adjacent flanges. Other engineers have equally recognised the fact that the roadway may most materially increase the effective chord area; but, instead of taking advantage of this fact to lighten their design or to increase the factor of safety, they have in repeated instances cut up the floor into a number of independent lengths so as to prevent any possibility of the calculated stresses being reduced by the action of the floor.

Judging from the second and third reports of the Indian Railway Bridge Committee, it would appear that Indian bridge engineers are as unscientific as the generality of those here or across the Atlantic. The reports in question are, to put it mildly, most disappointing documents. India has thousands of miles of railway and hundreds of railway bridges, included amongst which are some of the longest spans within the Empire. That this is the case could hardly be inferred from a perusal of the reports, since there is an almost complete absence of any reference to the actual behaviour of bridges under traffic. There is a great deal of discussion as to what formulas should be used for computing stresses, but practically none as to what stresses have been proved by actual experience to be safe or dangerous. Thus, Mr. D. H. Remfry, District Engineer on the Bengal-Nagpur Railway, "draws attention to the high secondary stresses in cross girders and rail girders, and considers it advisable to specify a higher coefficient for impact than the Government of India rules provide for; to allow for them or—an alternative which he prefers—reduce the working stresses in these members to 80 per cent. of the working stresses in the rest of the span." Now, of course, Mr. Remfry may be quite right, and a good *a priori* case can be made out for his conclusions, but such an expression of opinion from an engineer having numerous bridges under his charge should be backed by a statement that in girders subject to such stresses as perturb him, plates have cracked or rivets worked loose, and, as such partial failures were troublesome, it was expedient to reduce the stress. As matters stand, much of the report might well have been contributed by youthful lecturers on applied mechanics, necessarily lacking in prolonged practical experience and taking their opinions ready made from text-books, compiled in many cases by men with as limited practical experience as their own. Almost the only reference in the report to actual observations on how structures really do resist is a reference to the recorded experience of an eminent American bridge engineer.

The point under discussion was the proper thickness for the web of a plate girder. The history of this subject is of considerable interest as confirming the charge we have made against bridge engineers of frequently preferring formulas to facts. When the plate girder first came into use little was known about stress analysis, and proportions were settled largely by experiments on models. Later on it was recognised that a shear stress was compounded of a thrust and a tension, acting at right angles to each other, and it was forthwith assumed that the web plate could be considered as built up of a series of struts placed side by side. The further assumption was also made that the resistance of these struts could be calculated by a column formula. This was legitimate enough if the constants in the formula had been fixed by a study of the behaviour of the webs of actual girders. It was, however, generally assumed that the coefficients should be of at least the same order as those usually adopted for the Rankine-Gordon formula for the resistance of struts, and the result was an enormous increase in the thickness of the web plates of plate girders, which was in no way justified by actual experience.

In our issue of February 21, 1902, Mr. Graham Gribble analysed the web stresses in the plate girders forming the approach of Brunel's bridge at Chepstow, which was built in 1851. These girders are of 100 ft. span and are 7 ft. 7 in. deep over all. The web is ⅝ in. thick near the piers and ½ in. thick elsewhere. The webs are wholly unstiffened in the modern sense of the word, but have shown no signs of weakness, although carrying much heavier loads than were originally contemplated. Mr. Graham Gribble calculated the shear stress at the supports as 8 tons per foot run, whilst the bearing pressure on the rivets was no less than 13 tons, yet no rivets have worked loose. In spite of this successful experience, some of the rules which have been proposed and worked to for plate girder webs would have required the thickness of the Chepstow webs to be increased to not less than ten times its actual value, or else to be reinforced by numerous closely-spaced stiffeners. Sir Benjamin Baker recognised the absurdity of many of the formulas proposed, and in consequence tested the matter experimentally and found that in the case of a girder of 31 ft. 8 in. span, 3 ft. 6 in. deep, and having a web plate ¼ in. thick, the latter showed no signs of failure until the calculated shear stress amounted

to 4·3 tons per square inch. The stiffeners in this case were 6 ft. 4 in. apart.

Recurring again to the Indian report, Mr. H. H. Jellett, Chief Engineer to the Bengal-Nagpur Railway, "considers the question of impact is of paramount importance," whilst Sir Bradford Leslie holds that the effect "is not of much consequence, and might reasonably be neglected." Now, it is no doubt very difficult to prove a negative, but those who hold the positive view that impact is of paramount importance ought at least to be able to bring forward instances in which the ignoration of this consideration by the older school of designers had led to disaster or, at any rate, to excessive maintenance charges. Data of this kind have, however, never been brought forward, reliance being placed wholly on *a priori* reasoning, taken not infrequently from books and professional papers.

The most tremendous impact ever experienced by any bridge occurred when the central span of the second Quebec bridge was being hoisted into place, and, owing to the failure of a support, tipped off into the river. The remainder of the bridge, however, was not one penny the worse for its experience, though the conditions were exceptionally severe, as the stresses produced were reverse stresses.

In most cases the impacts on bridges are of a very much milder character, as is very clearly shown in some deflectometer diagrams accompanying the third report of the Indian Bridge Committee. These diagrams relate to a deck bridge of 100 ft. span and show very little difference in the deflection, whether the speed was 12 or 40 miles per hour, thus supporting the opinion expressed by Sir Bradford Leslie. The range of vibration, whatever its significance, was, moreover, a very small percentage of the total deflection. The instrument was applied to the centre of the bottom boom and was probably free from the errors which may arise when extensometers are applied to one side of a bridge member. It would throw an interesting light on the importance of vibrations if records were taken of the effect on the instruments used, of rapping the member with a hand hammer. It would take a great many repetitions of this to seriously injure a member of reasonable size, but we expect that many extensometers would record large vibrations. Incidentally, the Committee report the Frankel extensometer to be useless and unreliable, and are arranging for records to be taken with better instruments. If these records are to be collated with practical experience they may prove of considerable value. There will be unusually favourable conditions for such a comparison since it is proposed to allow a number of existing bridges which are due for replacement to be subjected to higher loads and stresses than are permitted by the existing regulations in the case of new structures. There will thus be an exceptional opportunity for detecting weak points and as the bridges are to be kept under careful inspection, no danger to the public can arise. There is an old Latin tag to the effect that no one becomes utterly base all on a sudden, and the adage is also applicable to structural steel. Even in engine work, where fractures arise from fatigue, the initial crack spreads slowly, giving ample warning of approaching failure, if inspection be duly maintained. Even the disaster to the s.s. Paris would have been averted had it been possible to keep under inspection the submerged tail shaft whose fracture occasioned the wreck.

## SOME PROPERTIES OF MOLYBDENUM STEELS.

The scope and application of molybdenum steels appears to be wider than that of any other types of alloy steel. Molybdenum structural steels were commercially developed during the war and served many very valuable purposes. One notable instance was their employment in the construction of the French "Baby" tanks, in which a ½-in. plate showed as great a resistance to bullet penetration as 3-in. manganese steel. In military aeroplane construction, molybdenum steel found numerous uses due to a large extent to its exceptional toughness and consequent reliability.

The earlier uses of molybdenum steel were as tool and magnet steels. At that time the ores of molybdenum were considered to be much scarcer than they are now known to be and sufficient production of molybdenum steel for structural purposes was not considered possible. But important discoveries of molybdenum ores in Canada and the United States have demonstrated that there is no immediate probability of the ores of molybdenum being exhausted, so that future supplies are assured for some years to come.

The first experiments with molybdenum steel were directed to ascertaining the direct effect of the presence of the metal in considerable quantities in ternary alloy steels. It has since been found that the chief value of the element is its indirect or intensifying effect in the more complex steels. In other words, its action in fractional percentages intensifies the excellent qualities of other important alloy steels supplying in these certain qualities without which they are limited in their application. Special steels in which chromium, nickel and vanadium play an important part are handicapped by the narrow limits of temperature within which heat treatment is effective. Outside of this small range, their high grade qualities are seriously impaired. For these molybdenum acts as a corrective and greatly extends the range within which heat treatment is beneficial. By its use, segregation is prevented, uniformity of texture is promoted and a degree of toughness imparted to steels otherwise more or less deficient in this quality. The beneficial effects of fractional additions of molybdenum are apparent in high-carbon steels, chromium and nickel steels, chromium-nickel steels and vanadium steels. It considerably increases the tensile strength of carbon and nickel steels. In chromium-nickel steels, probably through the formation of double carbides, additional tensile strength, hardness and other beneficial qualities are imparted. The penetrative effect of heat treatment in large sections is decidedly improved.

The purchaser of alloy steels for construction work has at his command a considerable choice of materials not differing greatly in their static and dynamic properties, but he is influenced in his choice of material by the relative efficiency of the product in responding to the various thermal and mechanical manipulations necessary to reach a finished product. The physical properties which may be developed by various types of molybdenum steel are well known. Chromium-nickel-molybdenum steel used on Liberty motors for aircraft service met the most exacting specifications, and records of the tests of physical properties show results superior to those obtained for any other types of steel used in work of this class. For general automobile requirements or machine construction, the chromium-molybdenum steels are usually recommended, but for special requirements it becomes necessary to use the more complex types such as chromium-nickel-molybdenum steel. As regards the supply of chromium ores, these are obtainable in sufficient quantity in most parts of the world, and there seems no reason why these complex steels should not be available so long as molybdenum is to be obtained.

The manufacture of these steels on a commercial basis is well established, and for this the electric furnace is chiefly employed. The United Steel Alloy Corporation of the United States commenced to make molybdenum steel in May, 1918, and since that time this company has produced approximately 25,000 tons of this class of steel. No serious difficulties have been encountered in any stage of manufacture, in melting, casting, rolling or cold-drawing operations. This steel requires the same care, but not greater, that is used for other alloy steels.

Molybdenum is added to steel in two forms, one as ferro-molybdenum and the other as calcium molybdate, but of these the first is to be preferred. The addition is made to the charge at the melting-point, this being found to yield the most homogeneous product. Some loss of molybdenum occurs in this addition by oxidation and volatilisation, but this is not serious. Molybdenum steel scrap can be used in the charge with advantage. While molybdenum apparently has no deoxidising or scavenging properties, it has on the other hand no deleterious effects on the working of the steel and, in fact, increases the range of temperature for rolling and forging. Molybdenum steels can be subjected to wide temperature changes for both hot working and heat treatment. This applies more particularly to the more generally used chromium-molybdenum types which will satisfactorily withstand considerably higher temperatures than the corresponding types of nickel and chromium-nickel steels. The outstanding features relative to the heat treatment of molybdenum steels are the extremely wide quenching temperatures available for practical heat treatment, the excellent penetrative effect of such treatment on large sizes, and the broad drawing range causing but slight modifications in physical properties.

Data published by most of the principal manufacturers of these steels, while showing great uniformity in static properties, are without information on the dynamic properties. To prove that impact as well as static properties show no marked variation with quenching temperatures ranging from 1,500 deg. to 2,000 deg. F., inclusive, a series of experiments have been carried out on molybdenum steel analysing as follows in percentages: 0·27 carbon, 0·66 manganese, 0·036 sulphur; 0·018 phosphorus, 0·08 silicon, 0·83 chromium, and 0·42 molybdenum. The size treated was ⅞ in. round, and the tests were drawn at 1,050 deg. F., after quenching in water at the temperatures indicated. The following results were recorded:—

| Quenching Temperature. | Elastic Limit. | Tensile Strength. | Elongation. | Reduction in Area. | Brinell Hardness. |
|---|---|---|---|---|---|
| deg. F. | lb. per sqr. in. | lb. per sqr. in. | per cent. | per cent. | |
| 1,500 | 140,000 | 163,500 | 18·5 | 62·7 | 319 |
| 1,600 | 139,500 | 161,700 | 17·0 | 63·1 | 319 |
| 1,700 | 138,400 | 160,200 | 71·5 | 61·7 | 321 |
| 1,800 | 138,300 | 158,500 | 18·0 | 61·5 | 319 |
| 1,900 | 139,600 | 159,600 | 16·8 | 57·9 | 317 |
| 2,000 | 140,000 | 157,000 | 17·0 | 59·0 | 317 |

Striking evidence of the improved penetrative effect of heat treatment as well as of the permissible use of the high temperatures desirable for the attainment of high physical properties, is manifested in a standard type of chromium-nickel-molybdenum steel used for crankshafts and connecting rods in aircraft work. The analysis range in percentages of this type is 0·22 to 0·30 carbon, 0·50 to 0·70 manganese, 0·025 sulphur (maximum), 0·030 phosphorus (maximum), 0·10 to 0·20 silicon, 0·70 to 0·90 chromium, 2·75 to 3·25 nickel, 0·30 to 0·50 molybdenum. Heats running 0·25 to 0·30 carbon were selected for crankshafts and those running 0·22 to 0·25 carbon were used for connecting rods. Physical tests were taken on a full size prolongation (approximately 4 in. diameter), and averaged over 28 tests taken at random showed elastic limit 130,000 lb. per sqr. in., ultimate strength 142,000 lb. per sqr. in., elongation 20·5 per cent., reduction of area 65 per cent., and Brinell hardness 303.

On a series of tests on 2-in. round bars, taken from the same type of steel after quenching in oil at 1,450 deg. F., and drawing at the temperatures indicated, the following results were obtained:—

| Drawing Temperature. | Elastic Limit. | Ultimate Strength. | Elongation. | Reduction in Area. | Brinell Hardness. |
|---|---|---|---|---|---|
| deg. F. | lb. per sqr. in. | lb. per sqr. in. | per cent. | per cent. | |
| 500 | 233,000 | 249,800 | 14·0 | 46·8 | 455 |
| 900 | 170,000 | 189,200 | 16·0 | 51·6 | 363 |
| 1,000 | 161,000 | 180,700 | 18·5 | 58·3 | 344 |
| 1,100 | 166,800 | 166,800 | 18·5 | 60·0 | 328 |

These results show the very small change in physical characteristics between samples drawn at 900 deg. and 1,100 deg. F. On another type of oil-hardened steel, the tensile strength was in excess of 200,000 lb. to the square inch for all drawing temperatures up to 1,000 deg. F., and the elastic limit in excess of 200,000 lb. to the square inch for all temperatures up to 900 deg. F.

Tests on another standard steel quenched in oil at 1,450 deg. F., and drawn at 400 deg. and 1,100 deg. F., respectively, gave results tabulated in the next column.

The most important mechanical operations to which steel is subjected in the manufacture of finished products are cold pressing, forming, heading

| Drawing Temperature. | Elastic Limit. | Tensile Strength. | Elongation. | Reduction in Area. |
|---|---|---|---|---|
| deg. F. | lb. per sqr. in. | lb. per sqr. in. | per cent. | per cent. |
| 400 | 302,000 | 336,600 | 10·0 | 22·4 |
| 1,000 | 190,000 | 202,000 | 15·0 | 50·1 |

and machining. An efficient response in the operations involving cold flowing of metal, effects savings in fabrication costs by diminishing the rejections of semi-finished and finished parts as well as maintenance costs of dies and tools. The merits of molybdenum steels in these respects have been well established. Molybdenum steel can be machined more easily than other alloy steels of equal physical properties. This has been established by the production results obtained on several thousand tons. In one instance quoted, it was stated that the tool grinding costs using molybdenum alloy steel were but one third as high as those incurred when dealing with a 3 per cent. nickel steel of the same hardness and with corresponding shop production. Front axles with Brinell hardness up to 340 machined as well as chromium-nickel steel of only 302 Brinell hardness.

## INCOMBUSTIBLES IN GAS.

THE publication of the Report of the Departmental Committee of the Board of Trade on "Gas Incombustibles," has quickly followed the publication of the Carbon Monoxide Committee's Report, with which we dealt in our issue of last week. The Limitation of Inerts Committee, as it has also been called, was appointed at the same time as the CO Committee, and examined its twenty witnesses also last winter and spring. The problems before the two Committees were similar; some of the witnesses appeared before both the Committees, and like the CO Committee, the Incombustibles Committee arrives at the conclusion that "it has not been established in evidence that restriction of incombustibles is necessary or desirable at the present time as a safeguard of the widely-varying interests of the gas consumer." The Committee, therefore, recommends that "at present no limitation be placed on the proportion of incombustible constituents in town gas." But they add that "after a period of three years, when the therm basis of charging for gas delivered has become general throughout the United Kingdom, and the difficulties under which some gas undertakings now labour are likely to have become mitigated, a further inquiry be instituted into the question comprised within our terms of reference." Thus, a definite period for further investigation is suggested by this Committee.

The Committee consisted of Messrs. James Hunter Gray, K.C., chairman; Mr. W. J. Atkinson Butterfield, M.A., F.I.C.; and Dr. Cecil Howard Lander, M.I.M.E., with Mr. W. H. L. Patterson as secretary. It examined representatives of the Sheffield Gas Consumers' Association, members of the firms of Messrs. Edgar Allen and Sons, Messrs. Hadfield, Messrs. Vickers and others; representatives of the railway companies, of the London County Council, of the National Gas Council, and of the Gas Companies' Protection Association, and some independent experts. By incombustibles the Committee understands—rightly, no doubt—not only carbon dioxide and nitrogen, but also oxygen, though oxygen is not an incombustible constituent of gas; for the consumer does not wish to pay for oxygen as part of his gas, considering that there is generally enough oxygen and air present to sustain combustion. All these constituents leak into the retorts from the air and the flues, when the walls are porous or the lids do not fit well and when a slight vacuum is maintained in the retorts, which may be necessary to prevent the escape of combustible gas.

The incombustibles dilute and deteriorate the gas. Since, however, the Gas Regulation Act of 1920 authorises the gas undertakings to charge for the thermal units supplied and to supply gas of whatever calorific power they prefer, subject to giving notice, and subject to taking, at their own expense, such steps as may be necessary to alter and replace the burners in consumers' appliances in such a manner as to secure that the gas can be burned with safety and efficiency, there was no ground for the Committee to recommend any limitation of incombustibles in so far as the presence of these inerts in the gas merely affects its calorific value. Their task was to investigate the extent to which an increase in the proportion of incombustibles affects the fitness or efficiency of the gas for any of the varied uses. That problem is wide and intricate indeed. Much of the evidence brought before the Committee concerned the use of gas fuel by the metallurgist and engineer. A poor gas, acceptable for general heating, may be unfit for steel furnaces, and the Committee hence had to inquire also into the advisability of restrictions in particular cases.

The problems had occupied the Fuel Research Board since 1917. In its report on Gas Standards of January, 1919, this Board had expressed the opinion that the imposition of a maximum limit of 12 per cent. of inert gas would in no way curtail the legitimate freedom of choice of raw materials and methods of production, and subsequent conferences of producers and consumers had agreed upon limits for definite periods, 20 per cent. for the first two years, 18 per cent. for the next two years, and 15 per cent. thereafter. Almost at once, however, this compromise had alarmed some gas managers. On the other hand consumers seemed to have very good reasons for complaint. The evidence of the Sheffield industrials, who during the war used about two-thirds of the town gas and are still wanting half of the gas, was very plain and strong. Whether or not the calorific power had gone down on account of an increase of inerts their furnaces and appliances would not work when the calorific power dropped from 560 B.Th.U. to 480 B.Th.U. and 448 B.Th.U. or when the pressure fluctuated considerably. They objected, as Dr. R. S. Hutton put it, to being placed at the mercy of the gas company which took little heed of the requirements of the consumer. The Committee was not satisfied by the evidence that reduction of the incombustibles *per se* would have avoided these troubles. They consider that the further suggestion of high incombustibles giving unsteady Bunsen flames had only been made on theoretical grounds. As regards incandescence lighting they had received evidence on tests of gas containing largely varying proportions of incombustibles from various districts, and that evidence did not reveal any serious detrimental influences.

The evidence on behalf of the gas industry was to the effect that gas engines and low-temperature operations were not affected to any but a negligible extent by the high percentage of inerts, provided high carbon dioxide percentages in particular were excluded. The Committee expressed agreement with this conclusion at which a committee of the Institution of Gas Engineers had arrived. As regards incandescence mantles the Committee reports that high $CO_2$ and nitrogen would mostly come into the gas together with the producer gas and water gas added to the straight gas which would balance the deleterious effect; the Committee, moreover, points out that the experimental evidence submitted relied on lighting experiments made with upright mantles whilst the modern tendency is decidedly in favour of inverted mantles. Air in even considerable proportion, and carbon dioxide, unless exceeding 8 per cent., are not considered detrimental by the Committee, provided the calorific power of the gas is kept above a certain minimum, *e.g.*, 400 B.Th.U., which would not be onerous to the gas industry at the present time.

The report draws attention to the present difficulties of the gas industry and to its possible future developments. The inferior quality of refractory materials and the difficulties of repairs and of maintaining adequate purifying plants were successfully pleaded by the gas industry. Dr. Charles Carpenter mentioned—his evidence is not quoted in the report—that whereas the German fire bricks had lasted 3,000 days, the average life of the British material was only 1,700 days or 1,800 days; he had in one case worked for a year with a material which eventually had a life of 300 days only. The chairman fully agreed that these considerations should be borne in mind, and they will, of course, be remembered. Yet they rather place the gas production on a special footing, and the point must not tempt us into a discussion of international trade restrictions. With respect to the future the Committee point out that a gas of high calorific value may become available requiring, for the purpose of easy distribution and use, considerable dilution with low-grade fuel gases containing high proportions of incombustible constituents. Alternatively gas of comparatively low calorific value and of high inerts might widely become available from processes involving internal heating of the retorts. Without expressing any opinion as to the applicability of such proposals the Committee does not wish to prevent the gas undertakings from availing themselves of these considerations.

We have already stated the recommendations made by the Committee. They also indulge in a suggestion of a reduction in the charge which might conceivably compensate the consumer for some detriment that he might suffer through a consequential alteration in the proportion of incombustibles in the gas. That optimistic ray will hardly penetrate far into our actual atmosphere. We regard the problems as serious. Grumbling over a bill for light and heat is a different thing from having to change back from gas to coke or electricity, and that seemed to be the question for some of the Sheffield witnesses. But matters will have to go on for the present.

## TRANSPORT IN ROUMANIA.

THE dominating factor at the present time in Roumania's efforts to re-establish herself is, according to a report recently issued by the Department of Overseas Trade, transport. Storage seems to make a good second. As most people know now the effects of the war on the country were in many ways very serious. The railways which were proving inadequate in 1914, suffered badly from the invasion of the country, the Germans withdrawing all the stock they could lay hands on, and destroying 59 railway bridges. The railways lost their personnel; the men on return found difficulty, as elsewhere, in settling down again to regular sustained industrial effort, and serious disorganisation and congestion followed. The locomotive question seems to have been the most serious point, though the permanent way was also in bad repair so that high speeds were impossible.

Since the armistice locomotive work has been still further complicated by the fact that engines have been purchased in Austria, Bohemia, Germany, Canada and the United States of America. The question of repair, therefore, has become serious, for though many new engines have been acquired none last very long without some repair or other, especially when attention is none too good. In addition France delivered a few engines to Roumania which Germany had handed over at the armistice, and these, of course, were not new machines. The efforts of the country to put its transportation on to a footing capable of assisting the re-establishment of industry has resulted in some peculiar experiments. A system for instance, was introduced by which anybody who paid for the repairs to a locomotive was entitled to use it for the transport of their own goods. It is stated that a profitable business sprang up in which traders got hold of locomotives in this way and were able to run fast services at high rates when apparently the Government could offer no facilities at all, or only with such serious delays as to make business impossible. This system was abolished after a time, but was replaced by another in which it was arranged that persons purchasing a locomotive of an approved type should have the exclusive use of the machine for three years, or until the charges at fast goods schedule amounted to the sum advanced for the purchase of the locomotive. The administration undertook to supply the necessary trucks. The difficulty in the way of this scheme appears to be that very few firms have sufficient money to enable them to purchase any locomotives, but it is stated that it is attracting support.

It is interesting to note how the whole life of the country is dependent upon the resuscitation of the railways. Speaking in very broad terms, the population is agricultural and depends upon its exports for its existence, or at any rate for life on a level with that of the so-called Western idea of

civilisation. Export of grain on the one hand means heavy seasonal transportation which the railway administration has been unable to cope with. In like manner life on the western scale entails large imports which have to be distributed over the country. Just as the railways have been unable to handle the export traffic, so have they failed with the distribution of imports, with the result that the ports have been hopelessly congested and much damage done to imported goods through storage in the open owing to the accommodation failing to meet the case.

Under the circumstances thoughts naturally turn to road transport, and the report we have referred to states that there would seem to be a good opening for British firms who could send to Roumania, and, apparently, run there lorries for the transport of the better paying classes of traffic. Road transport has, it admits, been tried with 2½-ton lorries and 2-ton trailers, but since the war repairs have been found to be very expensive. This seems to have been partly due to the very bad state of the roads causing heavy damage to the tyres, and partly to inexperience of the drivers, which last could be possibly overcome in the case of foreign companies making the venture. It may be mentioned that even under ordinary pre-war circumstances very few of the branch roads were made up, while the main roads to-day are in a very bad condition.

The state of land transport is paralleled by that of the water communications. The country is blessed in the Danube with a waterway of great value, even in years when the water is low. But the war resulted in a great reduction of the lighters and tugs on the river, with a consequent decrease of shipping facilities. Something like 110 lighters are reported to have been destroyed or sunk in the Danube, while 89 were taken to other waters during the war; some 22 tugs also disappeared, 14 being captured and 8 sunk. It is stated that no less than 100,000 tons of Danube shipping were sunk or confiscated by neighbours. In order to save lightering grain down to Sulina sea-going steamers have been taken up to Braila for loading, but the depth of the river being insufficient for full load the vessels have to return to Sulina or Constantza to complete the load, so that on the whole the situation is not much improved. The new territory of Roumania has greatly added to the river-served country, so that normally a great increase in facilities would be required, though instead the available facilities have been decreased, it is reckoned, some 30 per cent. It is suggested that there is an excellent opening for river craft, though it is doubtful whether Roumanian purchasers could be found. It must be remembered that with the value of the lei at its present level even a Roumanian millionaire is not a very rich man when it comes to buying things from this country, and it would probably be easier to do business if the supplier were prepared to retain an interest in the venture, than if the deal were confined to a mere sale, for instance, of river craft.

Roumania is normally a large exporter of grain, and it is chiefly this form of traffic which the transport situation has upset to such an extent, and this with the grain available for export only a portion of the total which used to be disposed of before the war. With her new territory it is estimated the country ought to be able to export about five or six million tons, whereas in 1920 she exported only 900,000 tons. Not until transport is improved can the country hope to export anything like its full quota.

The same influence has adversely affected the oil industry. The lack of locomotives and tank cars, and the unreliability of the pipe lines which have survived, coupled with the irregularity of the supply of electricity, has resulted in very poor production, since storage has been totally inadequate to supplement the lack of facilities of disposal. Some extremely good wells have been struck since the war, but the total yield has been less than that obtained by the Germans during their occupation in 1918, and at the present rate of drilling, which almost ceased in 1920, it will be very many years before the industry is really flourishing again. The position has been influenced adversely by the fluctuation of exchanges, and by Government regulations which have been well intentioned for the country as a whole, but have affected the large exporting industries rather seriously.

For those who may still happen to cling to the nationalisation of railways as the cure-all for all transport troubles we may note that in 1920, in the hope of improving matters a little, the Government of Roumania appointed commissions to classify goods for urgency of transportation. The scheme was rendered more or less futile by the Railway Administration giving precedence to its own traffic and after that to obtaining Governmental traffic and the War Office traffic, after which only could trucks be found for the transport of agricultural implements and other imports. It is, of course, very largely due to the complete failure of the transportation machine that the disorganisation of Russia is so complete, and that the country is threatened with the terrors of a large scale famine, for which it seems it will be impossible to organise adequate relief. Roumania, however, is on a different footing and is honestly giving her mind to setting her house in order, and as she is the producer of two of the essentials of life, if she can regain something of her pre-war export trade there is a prospect of her recovery from the waste of the recent years at an earlier period than a good many other nations.

## NOTES.

### THE DUTIES OF AN ARBITRATOR.

THE engineer is frequently called upon to act as arbitrator. When asked for the first time to undertake the task of deciding a dispute he may feel some uncertainty as to the extent of his powers; but he will not go far wrong if he follows the procedure adopted in a court of justice. Thus he should take care to decide nothing without having heard the parties or their legal representatives, unless he has been expressly invited to decide the matter referred to him on documents and without hearing evidence. A recent case in the King's Bench Division illustrates the danger which attends the arbitrator who decides without hearing the parties. A dispute which arose under a charter party between the French Government and the owner of a steamer was referred to arbitration under a clause providing that in the event of a dispute each party was to nominate a commercial man as arbitrator, and, if the arbitrators differed, they were to appoint an umpire. It appeared that the recognised practice in commercial arbitrations was that, unless the parties gave notice that they desired to attend personally or by their solicitors or counsel, the arbitrators presented the evidence and arguments to the umpire and had full power to act as advocates. The parties each appointed a commercial arbitrator, and the arbitrators appointed an umpire. The umpire, without hearing the parties, made his award on the case as presented by the arbitrators. On a motion to set aside his award on the ground of misconduct by the umpire, there was no evidence that the claimants had restricted the powers of their arbitrator in any way. It was held that in view of the practice and the authority given to the claimants' arbitrator there was no evidence of misconduct by the umpire, and the motion failed.

In this instance it will be seen that the Court was satisfied that there was a custom or usage amongst city men when acting as arbitrators to decide without hearing the parties; but it is conceived that the French Government will not find it very easy to appreciate how an English Court of Arbitration could have found against them in their absence. The "custom" or "practice" referred to may be commonly observed, but it does not appear to be very reasonable; and all persons who are concerned in a dispute which is referred to arbitration should take care to see that their right to appear before the arbitrators is preserved to them.

### THE FUSION OF CARBON.

IN our issue for May 13, on page 588 of vol. cxi of ENGINEERING, we mentioned the experiments of E. Ryschkewitsch on the fusion of carbon. Ryschkewitsch heated slabs of carbon joined to form a box frame by means of carbon electrodes fitted into the frame, the interior of which he packed with scaly graphite. In this and in other experiments, made in the graphite works of Kropfmühl, near Passau, he obtained evidence of incipient fusion and of a welding-up of the slabs with the carbon electrode. He did not claim, any more than the previous experimenters in this field, Despretz, La Rosa and Lummer had done, to have produced lumps of fused carbon. This claim is made by Siegmar Münch in the *Zeitschrift für Elektrochemie* of August of this year, pages 367 to 369, who recommends the use of very strong currents up to 1,500 amperes, and starts with graphite. His horizontal electrodes are graphite cylinders a few centimetres in diameter. Between these he places the graphite rod which is to be heated directly by the currents; the rod has a diameter of about 4 mm. and a length of 5 cm.; the one end of the rod is fixed to the anode, the other is gently pressed axially against the cathode. Heating in the air without having recourse to any insulation he finds that currents of 1,000 amperes made the rod as flexible as a white-hot nail, and that on increasing the current, fusion began at the cathode end, from which drops of fused carbon would fall. These drops were received in a ring-shaped graphite cup encircling part of the rod. At the same time the carbon would catch fire. By maintaining a suitable pressure between the rod and the cathode the whole rod could be fused. When fusion has set in, the current has to be reduced to suppress undesirable arcing. Münch says very little about his fused carbon, which he describes as having a metallic lustre. He gives a sketch of his arrangement, but does not reproduce photographs of his graphite, as Ryschkewitsch had done. Ryschkewitsch, writing in the same issue of the journal quoted, regrets the omission of further details and of analyses of the graphite used; we had to criticise his own communication for similar reasons. The explanation may be that neither experimenter obtained sufficient fused carbon or graphite for a reliable analysis. Though Münch states that the whole rod can be fused, he does not say how much fused graphite he actually produced. Heating in the open air, he admits, would not give many drops of fused carbon, because a great deal of the carbon would burn away, and there would also be great heat losses. Careful insulation and exclusion of the air at very high temperatures and current intensities are, of course, very difficult to secure, yet something might be done in that respect. Both experimenters intend to continue their researches.

## LITERATURE.

*Mine Rescue Work and Organisation.* By H. F. BULMAN, Associate Member of the Institution of Civil Engineers, Fellow of the Geological Society, and FREDERIC P. MILLS, Fellow of the Surveyors' Institute, Chief Officer of the Durham and Northumberland Collieries Fire and Rescue Brigade. London: Crosby, Lockwood and Son. [Price 12*s.* net.]

THE first instance of a life being saved by making use of a specially-devised breathing apparatus occurred in 1913, in connection with an explosion at a small colliery near Huddersfield. Probably little attention was given at the time to this successful application of a scientific device, but it proved the initial movement of a large organisation that now includes 50 central rescue stations, scattered through the coal-mining districts, directing the energies of some 6,500 carefully-picked and trained men, who devote themselves to the dangerous and arduous task of rescue work in collieries, when accident has created an irrespirable atmosphere that prevents the application of ordinary remedies. Legislation based on the Coal Mines Act of 1911, empowering the Home Secretary to issue regulations for improving the conditions of underground labour, has, of course, materially affected this rapid progress, but it would be wrong to ignore the spirit of self-sacrifice and devotion exhibited by the men themselves in giving loyal service to this development. This humane work is continually increasing, but the literature of the subject is scanty, for no efficient guide book exists that describes the nature of the training demanded from applicants for employment in rescue work, the mechanism of rescue apparatus, and its advantages and limitations in use. This

defect the authors have endeavoured to supply, and we believe the result will be useful to the public, who need information on the extent and character of this beneficent work, and will also be of value to the specialist who is preparing himself for a responsible and hazardous post.

First it is desirable to prevent the public entertaining an exaggerated idea of the utility or the purpose of rescue apparatus. Colonel Blackett, President of the Institution of Mining Engineers, who supplies a foreword to the work under notice, is careful to warn the public that increased safety does not lie in the training of large numbers of men in the use of breathing apparatus and similar appliances, though these must be on hand when needed. The work of these men comes only after the accident they are powerless to prevent, and whose consequences they can very imperfectly mitigate. The use of breathing dresses in poisonous gases is attended with such risks that the use of these should be regarded as a last resource, only to be employed when a well-defined purpose appears, which can be described in terms of locality and distance, and after all the ordinary means of seeking access to, and exploring, a mine has been intelligently used and exhausted. The apparatus is cumbersome, liable to disarrangement, and the radius of action is exceedingly limited. In the American service with the type of apparatus there in use, the rule is enforced that the "maximum straightaway unobstructed course should not exceed 5,000 ft., with a reserve crew at the fresh air base. Moreover, violent exertion while breathing oxygen is discouraged. Even when danger threatens to overtake a trained man, he is recommended to seek safety very slowly, not attempting to walk more than 2½ miles an hour. We are therefore far from the days when an individual outfit will be supplied to the miner with his lamp and other accessories. Increased safety must be sought in the prevention of fires and explosions, rather than in the rescue of victims after such disasters. The discussion of the means of prevention forms no part of the author's plans, but we must not overlook Colonel Blackett's earnest recommendation of the "study of the co-ordinated uses of all the other appliances by men with a finely-balanced sense of 'pitmatics,' and I live in hope that, with the almost certain safety which must result from the compulsory application of stone dust in coal mines, the need for so much 'rescue' work and so many 'regulations' may recede."

This is not intended to disparage the use of the breathing dress in its proper place, which finds a large field of usefulness in its own sphere. To illustrate its true function we may instance the success achieved at the Podmore Hall Colliery, North Staffordshire, wrecked from an explosion in 1918, when 155 lives were lost. The seam where the explosion occurred gave off fire-damp freely and was liable also to spontaneous combustion in gob fires. The onerous work of examination and repairing could be effected only by sealing off the forward areas by advanced stoppings, to be erected in positions where the atmosphere was irrespirable. Rescue brigades wearing "Proto-breathing" apparatus were organised, working in relays. For more than twelve months the work went on, no less than 34 stoppages being built in an atmosphere devoid of oxygen, and the seam was built up step by step, the last body being brought out thirteen months after the work had started. In another case where it was necessary to clear falls of stone, re-lay railway, build new stoppings, &c., three teams of five men lived during the working hours of four months on the oxygen supplied by their breathing apparatus. It was found possible to work under such conditions and in a temperature of 75 deg. F. for 90 minutes, with a rest of equal length. Such instances demonstrate the true purpose of a breathing apparatus, rendering possible the accomplishment of work which otherwise could not be attempted. But the term "Rescue-dress" is unfortunate, as it suggests too narrow a view of the general aim and usefulness of the various devices put on the market.

The construction of a suitable apparatus has engaged the attention of the ingenious for more than fifty years, but little real advance was made till science had demonstrated the exact nature of the requirements that had to be met. Thenceforward progress was rapid. Doctors Haldane and Leonard Hill, who may be regarded as true pioneers in this inquiry—one by his physiological work, the other by his researches on the effect of impure gases on the system—were able to place a distinct problem before the engineer and the mechanic, who have ably responded. The problem is how to convey to a man such a supply of fresh air that he may be enabled to work strenuously in a poisonous atmosphere for at least an hour. The apparatus must be portable, as light as is consistent with strength, and yet strong enough to withstand the severe usage to which it will be subjected while the miner travels over the scattered wreckage, the consequences of mine explosions. It must be mechanically so perfect that it will not fail to function, and must be of such simple construction that it can be manipulated in the dark, and even in smoke so dense that an electric lamp is of small assistance. Since it is impracticable to compress into a portable tank sufficient atmospheric air to supply the breathing needs of the wearer, pure oxygen is used, and in its general features a rescue apparatus consists of a small tank of compressed oxygen, a reducing valve through which the oxygen flows to a mouthpiece connected to the breathing bag by flexible tubes, and a receptacle containing caustic alkali for absorbing the carbon dioxide from the exhaled air. Valves, that open and close at each breath, prevent expired air from returning to the lungs before it has passed through a purifier.

Such an arrangement sounds fairly simple, but there are many difficulties to be overcome which have introduced great variety of detail. Among these may be mentioned the provision of means to prevent injury from the heat generated by the chemical action, which takes place in the purifier, between the caustic soda and the carbon dioxide and moisture in the expired air, and the adoption of precautions to make the apparatus absolutely airtight in order to prevent the smallest leak inwards from the outside atmosphere. An important chapter is devoted to the description of the various kinds of apparatus that have been designed to secure the main end, and of the particular details that have been adopted. After thorough discussion, the authors apparently attach entire approval to the Brigg's form of construction, which has been but recently introduced to the public, and has not been fuly submitted to expert criticism or the severer test of actual trial. In a Canadian competition between the several kinds of apparatus known as the Proto, the Gibbs, and the Paul, this last, an American invention of recent date, all three proved equally efficient when no strenuous exertion was required of the workers, but when the strain was increased, signs of fatigue were exhibited after an hour's exertion by those wearing the Proto and Gibbs' apparatus, while the Paul proved its efficiency under all tests, ensuring a plentiful supply of oxygen at a fairly low temperature, and an almost complete absorption of the carbon dioxide. The tale unfolded is one of continual progress, though perfection may not be reached, for capable designers instructed by matured experience continually improve on earlier attempts.

Another chapter possessing very considerable interest, even for those who are not likely to make trial of the ingenious appliances mentioned, is devoted to the description of apparatus other than those connected with the supply of oxygen. The smoke helmet is one which often gives very good results where the irrespirable atmosphere to be traversed does not exceed 60 yards or 70 yards from good air. This is a simple device by which ordinary atmospheric air is delivered to the helmet by a pump or blower fan through lengths of armoured hose. In its simplest form, this contrivance dispenses with the pumping machinery and the air is drawn by the action of the lungs through a tube having an airtight joint with the mouth and suitable valves for inlet and discharge. The distance at which such a device can be used is limited by the friction of the air through the tube, and probably would not exceed 20 ft. or 30 ft. Air-sampling tubes, hand pumps, gas-detecting apparatus and various other appliances all come under review, but we see no mention of the Burrell gas detector, which is said to give excellent results in American practice. For detecting the presence of inflammable gas it has an advantage over a flame safety lamp, because its use eliminates any error arising from defective vision, and the exact amount of gas present can be quickly determined within 0·1 per cent. On the other hand, we are told of another American device in which a specially-prepared chemical, whose composition is not given, changes colour when brought into contact with carbon monoxide. This should prove useful as the mechanical arrangements are very simple and the evidence decisive. The Geophone, an adaptation of mechanism found useful in the war for determining the direction of the underground mining operations of the enemy, fulfils now a more fruitful purpose by assisting imprisoned men to make known their whereabouts to a rescue party. Whether the device has found practical application in mining accidents is not stated, but the arrangements are ingenious.

To those who propose to take up rescue work, or are actually engaged in it, much useful information is given on the necessary preliminary training, the essential requirements of the Home Office, and the design and equipment of rescue stations. The book collects and makes available a quantity of floating information and valuable experience that will benefit both the recruit and the instructor. But as Colonel Blackett hints, prevention is better than cure, and we hope the authors will see their way to supplement their work by detailing the principles, and placing in the hands of those most immediately concerned, the means of becoming acquainted with the methods that have been devised for securing greater safety in coal-mining.

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*Applied Colloid Chemistry. General Theory.* By WILDER D. BANCROFT, Professor of Physical Chemistry at Cornell University. New York and London: The McGraw-Hill Book Company. [Price 18*s.* net.]

THAT the literature on colloidal phenomena and their theoretical bearing is advancing at a far more rapid rate than applied colloid chemistry, is largely due to the increasing tendency of physical chemists of regarding most materials and reactions as intrinsically colloidal. If textiles and cements be colloidal, the manufacturer has not yet found himself obliged to modify his methods for that reason. At the same time the dyer is quite aware that he is dealing with colloids, and most manufacturers understand by this time that they should make themselves acquainted with the science of their technical processes. What they may complain about is that scientists do not always facilitate such studies, even when they write on applied science.

The preface to the "Applied Colloid Chemistry" by Professor W. D. Bancroft, of Cornell University, Ithaca, New York, is not encouraging in this respect. "This volume on general theory," the author writes, "should be followed by at least one volume on each of the following subjects: Silicate industries; paints; plastics; fibres and dyeing; photochemistry and photography; petroleum; ore flotation; foods and beverages; soils and crops; biology and medicine. Allowing a minimum of three years to a volume it seems very improbable that I shall write all of these single-handed. With the general theory of the subject once cleared up, there is no reason why the other volumes should not be written by people whose knowledge of the special subjects is much greater than my own." The personal note struck is sympathic. But is there really a need of all these special volumes from the colloid standpoint? Might not the general theory have been exposed in such a way as to admit at least of grouping some of the special technical subjects?

Professor Bancroft has adopted the main title: "Applied Colloid Chemistry," with the sub-title "General Theory." Strictly speaking, he gives neither. His references to applications are limited to a few lines; they are not needed in this volume. But his theory is too broad without being sufficiently specialised. It suffers from the inclusion of subjects such as rainbows, and the colour of the iris and of the tree-frog. To devote 126 pages out of a total of 333 pages to absorption and adsorption looks a little like monopolising general problems of physical chemistry for his own particular purpose. No

doubt sorption is widely colloidal. But Professor Bancroft is greater in detail than in general exposition, and a good deal of his detail might have been left out. With the chapters on Surface Tension and Brownian Movements, on Coalescence and on the Preparation and Properties of Colloids we are certainly right in the subject. But he speaks of condensation methods and dispersion methods of preparation, without explaining his terms, and the reader may fail to see the forest for the trees. Professor Bancroft is known as a most painstaking searcher and worker. We are everywhere interested by his quoting forgotten experiments and his pointing out suggestive analogies. Yet he limits himself in Chapter XII on Gases and Solids in Solids to the colours which metals and their compounds impart to glasses, and though frequently referring to Zsigmondy, he omits to say that the colour is not merely dependent upon the size of the particles. We do not wish to dwell on such omissions, however, nor to call for a more mathematical treatment. The point is that too many pages of the volume read as if they had been incorporated from Professor Bancroft's own abstract notes. His abundant literature references, very welcome to the specialist, testify more to his diligence and thoroughness, than to his gift as a lucid and systematic exponent of difficult problems.

## BOOKS RECEIVED.

*Principles of Radio Communication.* By J. H. MORECROFT, assisted by A. PINTO and W. A. CURRY. New York; John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 45*s.* net.]

*United States Geological Survey.* Bulletins No. 713 *Geography, Geology and Mineral Resources of the Fort Hall Indian Reservation, Idaho.* By G. R. MANSFIELD. *With a Chapter on Water Resources.* By W. B. HEROY. [Price 50 cents.] No. 715—K. *The Divide Silver District, Nevada.* By ADOLPH KNOPF. No. 715—L. *The Mogollon District, near Mexico.* By HARRY G. FERGUSON. No. 716—G. *Coal in the Middle and Eastern Parts of San Juan County, New Mexico.* By CLYDE MAX. BAUER and JOHN B. REESIDE, Junior. No. 716—H. *Character of Coal in the Thomas Bed, near Harrison, West Virginia.* By MARIUS R. CAMPBELL. Professional Paper No. 129—A. *Lithologic Subsurface Correlation in the "Bend Series" of North-Central Texas.* By MARCUS I. GOLDMAN. Washington: Government Printing Office.

*Banca Commerciale Italiana, Cenni Statistici sul Movimento Economico dell' Italia. Le Imposte e Tasse in Italia. Le Imposte e Tasse Italiane Nelle Nuove Provincie.* Milano: Banco Commerciale Italiano.

*The Electric Furnace.* By J. N. PRING, M.B.E., D.Sc. London: Longmans, Green and Co. [Price 32*s.* net.]

*City and Guilds of London Institute. Department of Technology. Programme for the Session* 1921–22. London: John Murray. [Price 3*s.* 6*d.* net.]

*The Motor Car Index*, 1921. Compiled by J. F. ATKINSON. London: J. F. Atkinson and Co. [Price 10*s.*]

*Board of Education, South Kensington. Classification for Works on Pure and Applied Science in the Science Library, the Science Museum.* Second edition. London: H.M. Stationery Office. [Price 18*s.* net.]

*Dienst Voor Waterkracht en Electriciteit in Nederlandsch-Indie. Tweede Jaarverslag*, 1919. Bandoeng: N.V. Drukkerij vh A. C. Nix and Co.

## INDUSTRIAL NOTES.

THE eighty-seventh quarterly balance sheet, to June 30, recently issued by the General Federation of Trade Unions, shows a total of 132 societies affiliated, with a gross membership of 1,546,746. The investments in War Stock, War Loan and War Bonds, &c., and cash in hand, total £92,496. In his report the secretary, Mr. W. A. Appleton, states that, as was clearly anticipated, the return to the normal industrial and commercial conditions has been accompanied by unemployment more serious than has occurred on any similar form of industrial disturbance within the recollection, or even the historical cognisance, of the people of this country. In one of the basic trades—the steel trade—it has been stated that 90 per cent. of its members have been unemployed. Not only the steel workers, but the ironstone miners and everyone connected with the getting of ironstone, the smelting of steel, has suffered incredibly. Dealing generally with trade unions, Mr. Appleton says the large influx of new members during the war period forms an unstable membership which has added to the liability and is increasing the difficulties of some unions; their unemployment funds are depleted, and their resisting capacities grievously weakened. "There are many things the trade union movement needs," adds Mr. Appleton, "if it is going to be successful. It needs, among others, a better understanding of its relation to trade and commerce."

A very clear illustration not only of the coal trade but of the general trade of this country is afforded by the following figures of coal exports for the month of July, 1921, 1920 and 1913.

| | Tons. | Value. | Value per Ton. |
|---|---|---|---|
| July, 1921 .... | 816,000 | 1,560,000*l.* | 38*s.* 2*d.* |
| July, 1920 .... | 2,097,000 | 8,928,000*l.* | 85*s.* 2*d.* |
| July, 1913 .... | 6,975,000 | 4,846,000*l.* | 13*s.* 10*d.* |

In our issue of last week we gave an example of trade union restrictions. Another example has since come to our notice. Contractors who are building a number of houses at Scunthorpe, Lincolnshire, in their desire to finish the work as rapidly as possible introduced a system of payment by result. A few bricklayers were hired under the scheme at the local union rate of 2*s.* 1*d.* per hour, and at the end of the week, their job being measured up, it was found that each man was entitled to 5*d.* above the local rate, the wage thus being 2*s.* 6*d.* per hour. The men were quite satisfied with the scheme, which was working quite smoothly, but officials of the Bricklayers' Union stepped in, and on the excuse that this was a piecework system, they called the men out on strike. Men in other trades have come out in sympathy, and 300 men are affected.

We are glad to state that the wages dispute in the chemical trades, to which we referred in our two last issues, was settled at a resumed conference held in Manchester last Friday between a representative of the Ministry of Labour and delegates from the trade unions forming the workers' side in the Joint Industrial Council for the trades in question. The men have accepted a reduction of 1½*d.* per hour to date from August 1, and a further reduction of ½d. per hour from October 1; after that, wages are to be stabilised until the end of the year.

A conference has been arranged for the 23rd inst. in London, between the Shipbuilding Employers' Federation and the Federation of Engineering and Shipbuilding Trades; its object is to discuss the employers' intimation that the payment of the 12½ per cent. and 7½ per cent. bonuses is to cease, in view of the provision in the order, granting these bonuses, to the effect that they should not continue in force after the termination of the present war. By Order in Council dated the 10th ult., the 31st ult. (last Wednesday) was the date for the official termination of the war. The coming into force of this Order in Council affects, as from the 1st, a number of industries and businesses throughout the country from the point of view of reduction in wages.

The apathy which is unfortunately so generally in evidence when the voting takes place for the election of local councillors, is threatening to result in a still further increase in rates—which even now stand at an unprecedented high figure. Following the example set by Islington where the guardians have granted an increased scale of outdoor unemployment relief, the unemployed in other boroughs are moving with a view to obtain similar favourable conditions. They demand, per week, 15*s.* for the husband, 15*s.* for the wife, 7*s.* 6*d.* for each child under 16, 15*s.* for rent, and 3*s.* 6*d.* for coal. During the time this allowance is being granted out of the rates, i.e., out of the wages and salaries of the remainder of the community—already taxed as it is almost past bearing—little eagerness may be expected from the unemployed as regards finding work. There have been many instances of this state of things in former months, but on a reduced scale as regards the "dole." The Middle Classes Union is reported to be protesting against this demand by the unemployed; the greater portion of the burden of this new "economic" departure in the administration of local funds will fall upon the middle classes, and it is to be hoped the efforts of this Union will succeed. We fear, however, that the action is taken too late, and that a heavy bill will have to be paid before the next local elections take place.

Correspondence which has taken place between the National Sailors' and Firemen's Union and the Transport Workers' Federation has just been published. The National Sailors' and Firemen's Union has withdrawn from the Transport Workers' Federation owing to the action of the Triple Alliance during the recent coal strike. The Transport Workers' Federation and Triple Alliance are charged with putting the power of the Alliance to political uses in directions to which the majority of the workers are opposed. Mr. R. Williams' reply does not seem to have convinced the Sailors' and Firemen's Union that they were under a misapprehension. The Hull Seamen's Union has now taken similar action and withdrawn from the Transport Workers' Federation.

An agreement has been reached, it is stated, between the Amalgamated Engineering Union and the railway companies regarding the railway shopmen. The Amalgamated Union claims to represent the craftsmen in the railway shops, and has refused to recognise the right of the National Union of Railwaymen to negotiate for these workers. Under the present settlement a recommendation is to be made for the wages of shop and shedmen to be reduced by 6*s.* per week as from August 15. It may be added that the National Union arrived at similar terms with the railway companies a short while ago.

## TROLLEY OMNIBUSES AT YORK.

THE attractiveness of combining the merits of a tramway system with the advantages of the motor-omnibus have led to several suggestions of a compromise between these two methods of passenger transport. The tramcar has the drawback of requiring a costly track, which, moreover, is a nuisance to other road-users, and its inability to swerve involves great hindrance to itself and to other vehicles when traffic is congested. The motor-omnibus, on the other hand, is of considerable mechanical complexity and cannot take advantage of the economical generation of power at a central station. The obvious compromise is a railless vehicle taking its power from overhead trolley wires, but yet able to move from side to side of the road. Such "trolley-'buses" have been used for several years in various towns, both in this country and abroad, and on Wednesday last, a party of engineers inspected the recently-installed railless system at York at the invitation of Messrs. Railless, Limited, of 56, Moorgate-street, E.C.2, who designed and supplied the vehicles.

The route over which the York trolley-'buses are operated is about 1¼ miles in length, from the Market Square of the City to Heworth. Several very narrow streets have to be traversed and the turnings are numerous and sharp, the route being indeed an impracticable one for tramcars. The trolley-'buses, four in number, are of the single-deck type, with seats for 24 passengers. They are light vehicles, with the entrance close to the driver's seat, so that they can be operated by one man who also supervises the payment of fares as the passengers enter. Each trolley-'bus has two 23 brake-horse-power motors, one motor driving each of the back wheels by means of worm-gearing. There is no other gearing on the chassis, and a differential is, of course, unnecessary. The motors are operated by an ordinary series-parallel controller of the tramway type. Hand and pedal operated service brakes act on the rear wheels and a pedal operated emergency brake on the motor shafts.

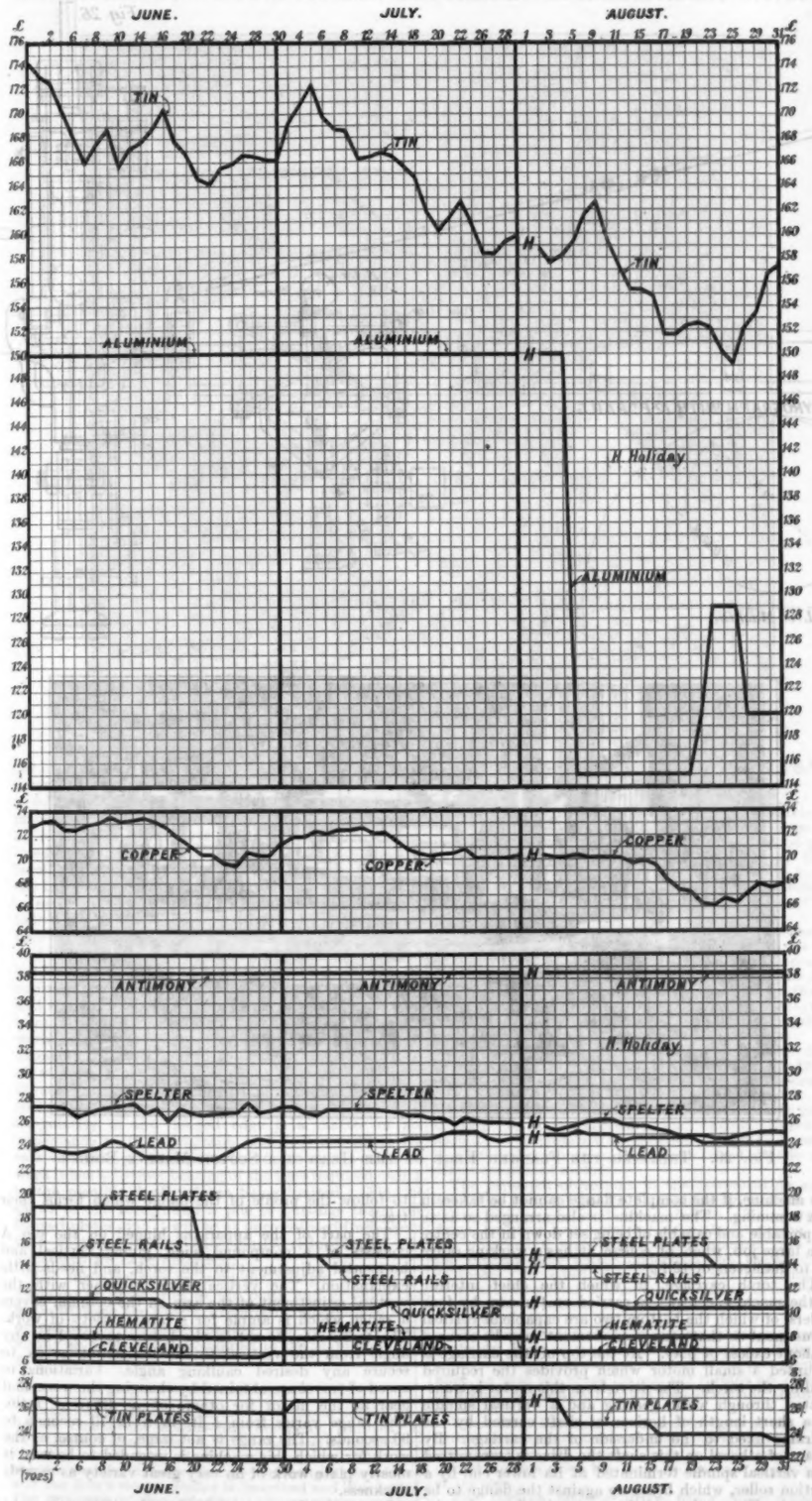
The overhead equipment is exactly similar to that of a tramway except that the trolley wire is duplicated to afford a return circuit for the current. The trolley wires are 21 ft. from ground level, and the 17 ft. trolley poles on the bus permit the vehicles to travel at a distance of 15 ft. on either side of the centre of the wires. The trolley wheels are somewhat deeply grooved, and ample freedom of swivelling is arranged for. The trolley-'buses thread their way through traffic with all the facility of a petrol bus, and we are assured that cases of the trolleys leaving the wires are practically unknown. The silence of the vehicles, compared with the noise of a tramcar, or even of a motor bus, was very noticeable. We were informed that, exclusive of capital charges, the cost of running was 11·5*d.* per car mile, this figure including power, tyres and driver's wages. Current was supplied at 2*d.* per kw.h. and the consumption was 1·42 kw.h. per car mile, measured at the station.

THE INSTITUTION OF AUTOMOBILE ENGINEERS; INFORMAL MEETINGS.—Arrangements are now being made by the Institution of Automobile Engineers for holding a series of informal meetings before the London, Birmingham, Manchester and Glasgow Centres during the winter. These meetings are designed to bring before the members new accessories in connection with the automobile (such as tyres, carburettors, easy-starting devices, and such like), and to allow of their advantages being freely canvassed and discussed. Any firm who have suitable specialities which they are willing to demonstrate at any or all of the centres are requested to communicate with the Secretary, 28, Victoria-street, London, S.W.1.

PERSONAL.—Messrs. Charles Churchill and Co., Limited, 9–15, Leonard-street, Finsbury, E.C.2, state that they have been recently appointed the sole agents for Great Britain for the National Acme Company, Cleveland, Ohio, U.S.A., who manufacture Gridley automatics, both single and multiple spindle, Acme automatics, Namco die heads and collapsing taps and numerous auxiliary machinery such as bolt threaders, screw holders, multiple spindle drillers and screw head shaving attachments, &c. —Mr. N. G. Gedye, M.Inst.C.E., informs us that having relinquished his appointment as Chief Civil Engineer for Docks, Harbours and Inland Waterways, to the Ministry of Transport, he is resuming practice as a Consulting Engineer, with offices at 5, Victoria-street, S.W.—We are informed by the Aster Engineering Company, Limited, of Wembley, Middlesex, that they have taken over all the "Anthony" patents for steam pumps, regulators and gearless pumps.

## DIAGRAMS OF THREE MONTHS FLUCTUATIONS IN PRICES OF METALS.

*(Specially Compiled from Official Reports of London Metal Markets.)*




NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

## THE LATE MR. PETER COOPER HEWITT.

WE regret to have to record the death of Mr. Peter Cooper Hewitt, the distinguished American scientist and inventor, who passed away in the American Hospital at Neuilly, Paris, on Thursday, the 25th ultimo, from pneumonia following an operation for intestinal trouble. Mr. Hewitt was born in New York on March 5, 1861, so that he was in his 61st year at the time of his death. He was educated at the Stevens Institute of Technology, Hoboken, and at Columbia University, which university conferred on him the honorary degree of Doctor of Science in 1903.

Although he inherited a large fortune from his parents, his father, Mr. A. S. Hewitt, being a former Mayor of New York and a Member of Congress, Mr. Cooper Hewitt devoted himself very largely to scientific research work, in which field he attained an international reputation. In this country, his best-known work was in connection with the development of the mercury-vapour lamp which bears his name, and the mercury-arc rectifier for producing continuous current from an alternating-current supply. For the manufacture and sale of these appliances he founded, in conjunction with Mr. George Westinghouse, the Cooper-Hewitt Electric Company, of New York, and the Westinghouse Cooper-Hewitt Company, of London, the latter firm now being known as the Hewittic Electric Company, Ltd., of 80, York Road, King's Cross, N. 1. Recent developments in connection with these rectifiers have enabled them to be made for continuous current outputs of 150 amperes with a single glass bulb, whereas the largest size formerly manufactured had an output of only 40 amperes.

Mr. Hewitt's work was, however, by no means confined to mercury-vapour apparatus, but extended to fields as diverse as wireless telegraphy and telephony, and the electrical welding of steel. He also made numerous experiments in connection with the evolution of seaplanes. Many of his discoveries were of considerable commercial value, and Mr. Hewitt was a director of several mining, electrical and railway companies. He was a member of the American Geographical Society, the Society of Naval Architects and Marine Engineers, and the Inventors' Guild, and was also associated with numerous philanthropic societies and organisations for the encouragement of the arts. Mr. Hewitt had resided in Paris for several years past, but paid frequent visits to New York in which city a very wide circle of friends will mourn his loss.

## THE ELLISON INDUSTRIAL SWITCHGEAR.

THE works of Mr. George Ellison, at Perry Bar, Birmingham, were thrown open by the proprietor for inspection by a party of guests, on Thursday of last week, the object of the visit being to examine the various types of industrial switchgear manufactured by the firm and to observe the methods of production employed. The Ellison switchgear is too well-known to need a general description, the interest lying in the details which can only be adequately dealt with in a special article. This, we hope, to be able to publish at an early date. Meanwhile, however, we may say that the works, which give employment to about 700 men, comprise a number of excellently-lighted single-floor shops, with well-organised stores, mess-room accommodation, and all the appurtenances of a modern and efficient factory. Manufacturing is carried on, as indeed it always has been since the foundation of the works about a quarter of a century ago, on "mass-production" lines, all details being standardised and made for stock. The main output of the factory consists of totally-enclosed iron-clad units for the control of slip-ring and squirrel cage induction motors, circuit breakers, crane controllers, &c. The units can be built up into complete switchboards, suitable for every kind of industrial purpose, and intended to cover the field between the ordinary switch and fuse distribution board and the elaborate installations of the larger power stations.

The units are supported on cast-iron stands, and are bolted together to form a compact, totally enclosed, weather proof, and mistake-proof switchboard, which will safely withstand the roughest use. The circuit breakers are bolted to a chamber of steel plate, which contains the isolating switches and busbars, and upon which are mounted the necessary instruments. Interlocking devices prevent the circuit being inadvertantly opened by means of the isolating switches, as these cannot be operated unless the circuit is open. In addition to mechanical interlocking where necessary the units are also electrically interlocked, to ensure that the various operations are performed in correct sequence. A feature of all the Ellison gear is the sound mechanical design of the various details, the reproach of "solder and sealing-wax" having no application to any of its features, however trivial they may be, in appearance.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—At a meeting of the Privy Council held at Buckingham Palace on Wednesday, the 10th inst., the petition of the Institution for a Royal Charter of Incorporation was approved, and a Royal Charter has been granted. His Majesty the King has been graciously pleased to intimate his willingness to become patron of the Institution.

# THE PYROGRAPH OXY-ACETYLENE CUTTING MACHINE.

CONSTRUCTED BY THE DAVIS-BOURNONVILLE COMPANY, ENGINEERS, JERSEY CITY, N.J., U.S.A.

*Fig. 25.*

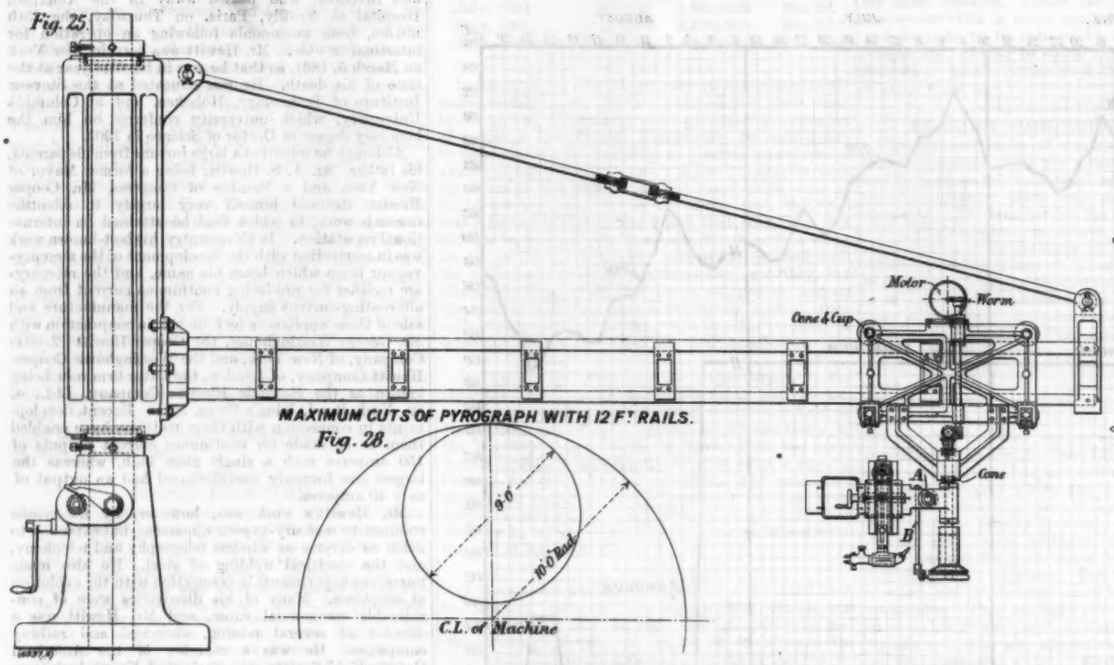
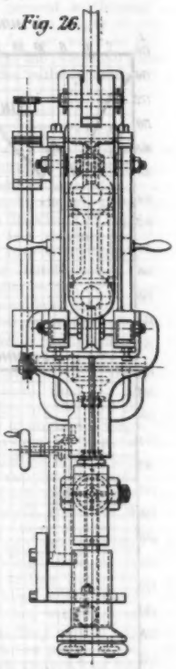



*Fig. 26.*

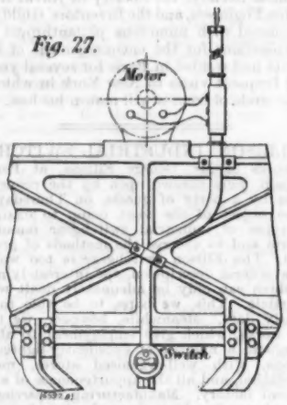


MAXIMUM CUTS OF PYROGRAPH WITH 12 Ft. RAILS.

*Fig. 28.*




*Fig. 27.*



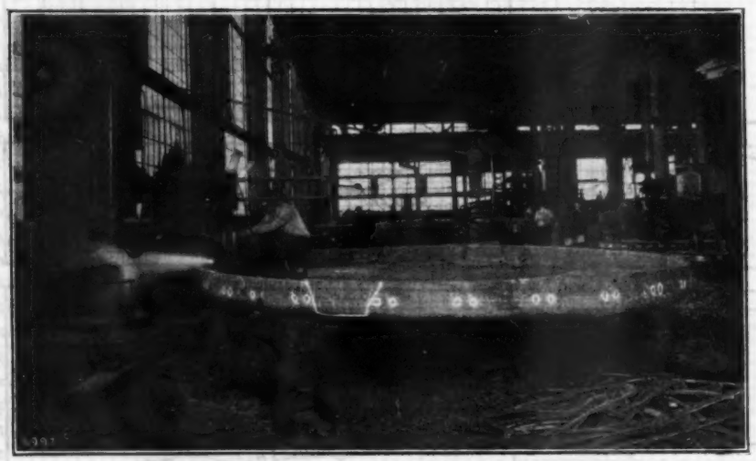



FIG. 29. TRIMMING THE FLANGED EDGE OF THE HEAD OF A SCOTCH MARINE BOILER.

## OXY-ACETYLENE CUTTING MACHINES.

(*Concluded from page* 311.)

THE machine we describe in this concluding article is intended mainly for boiler shop use. It is named by its makers (the Davis-Bournonville Company, of Jersey City, N.J., U.S.A.), the Pyrograph, and is shown in Figs. 25 to 30, on the present and opposite pages. It is designed for trimming and bevelling to a caulking edge, the flanges of boiler heads, fire-boxes, combustion chambers, &c. In fact, flanged edges which normally would have to be chipped by hand or with pneumatic tools, or sawn, can be trimmed off to a clean enough edge to satisfy inspection authorities, and require no further dressing before caulking. The main principles of the machine will be clear from our general drawing, Fig. 25, and from the view, Fig. 29, showing a large Scotch marine boiler head being trimmed off.

It will be seen to consist of a column and radial arm, the latter forming the support for a carriage to which is attached a torch. The column is telescopic, the vertical movement of 18 in., which regulates the height of the arm, being controlled by a ratchet and handle. A casting fitted with ball bearings is mounted on the column, and to this at its lower end is fixed the radial arm. To its upper end is attached a turnbuckle stay extending to the outboard end of the arm. The arm consists of two tubes held apart by clips, and 12 ft. in length. As shown in Fig. 28, a machine of this size can conveniently cover a flanged plate 9 ft. in diameter, or a semicircular plate of 20 ft. diameter. Large work can be, of course, if necessary, re-set under the machine, if the complete flange cannot be taken in one trimming. The machine is also arranged so as to be portable and capable of being set down in the centre of a large job, when, of course, it has a working range up to diameters of 12 ft.

The torch carriage, in which the chief interest of the machine centres, is carried on the arm by four rollers, of which the bottom two are capable of vertical adjustment so that ease of movement may be secured without excess of play. At the top of the carriage is mounted a small motor which provides the required feed for the torch. The drive from this motor is transmitted through worm gearing and a vertical spindle to a short length of horizontal shaft carried by the V-frame fixed to the underside of the carriage. By means of a bevel on this shaft the drive is transmitted to a vertical spindle terminated at its lower end by a friction roller, which bears up against the flange to be dressed. This roller is held up to the flange by the weight of the torch and holder, pivoted on a pin A, Fig. 25. The torch holder is fitted with a rod and frame B, at the lower extremity of which are two small idler rollers. The flange is gripped between these idlers and the friction drive roller previously mentioned, and the arm and carriage are thus moved automatically to follow the profile of the flange which forms their track.

The part of the apparatus hinged on the pin A consists of a compound slide, giving vertical and horizontal adjustment to the torch, and needs little explanation. The vertical slide, together with the vertical adjustment of the arm on the column, covers a range which is ample for a large variety of work. The torch may be set in the holder to bevel at any angle from the vertical to the horizontal, so as to secure any desired caulking angle. Variations in speed of travel are obtained by changing the worm and gear at the motor for others of a different ratio. The range varies from 1 ft. in from 70 seconds to 90 seconds. The range is not large, of course, as the work for which this machine is intended to be used is mostly plate work of no very great variety as regards thickness.

The feed of the machine can be instantaneously interrupted by lifting up the torch holder hinged on the pin A. The driving roller is protected by a fire-proof shield which is clearly seen in our view, Fig. 30. As in the machines described in our previous articles the pre-heating flame is first turned on, and when the cutting oxygen is turned on the motor is automatically

# PYROGRAPH OXY-ACETYLENE CUTTING MACHINE.

**CONSTRUCTED BY THE DAVIS-BOURNONVILLE COMPANY, ENGINEERS, JERSEY CITY, U.S.A.**

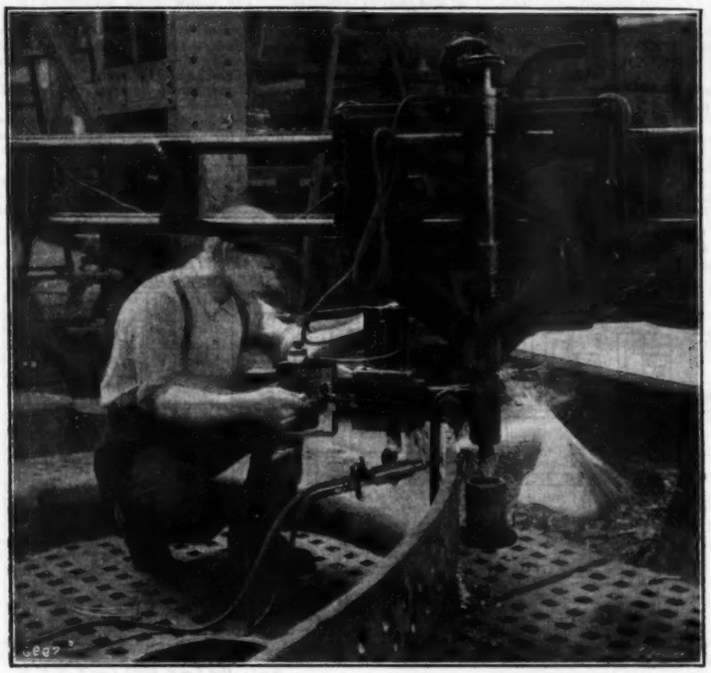


FIG. 30. TORCH AND CARRIAGE OF THE PYROGRAPH.

cut in, and the torch commences to move round the flange, the arm swinging freely to allow the carriage to follow any contour. If the plate is set properly the machine will cut a bevelled flange of uniform height all round without further adjustments. If a scribed line is made the torch can be made to follow it and the levelling of the plate need not be so precise. As a rule the latter system is generally adopted, as the operator in any case follows the torch, and its adjustment to follow the line is a simple matter and, on the whole, time is saved in the setting.

We are informed that flanged combustion chamber heads of ¾ in. plate and a periphery of 27 ft. can be easily trimmed and bevelled to a caulking edge in half an hour, exclusive of setting up, which could not be approached by chipping or sawing or other machine work. The difference on large heads of 16 ft. or so diameter, between the pyrograph cutting at the rate of, say, 10 in. per minute, and ordinary chipping, or the setting and cutting time required for a large machine tool for this class of work is very marked indeed. The irregularity of the flanged edge is a matter of no importance to the Pyrograph and does not affect its rate of cutting, whereas with trimming or machine work it has a distinct bearing of the time required owing to the possible depth of cut being limited. Fig. 29 shows in the foreground a pile of cuttings taken off flanged plates, and it will be at once realised from these that cutting time is enormously reduced by the apparatus we have described.

The machine may be used for straight cutting by clamping an angle iron to the plate and gripping the angle between the rollers. Similarly, any cornice line, or regular or irregular opening can be cut by providing an angle templet clamped to the plate and used to guide the torch.

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CHEMICAL MANURE MACHINERY.—A useful publication by the Sturtevant Engineering Company, Limited, of 147, Queen Victoria Street, E.C.4, deals with machinery for the manufacture of chemical manures. The first chapter deals with the preliminary crushing of phosphates and the firm's rotary crusher is described and illustrated. The processes of fine grinding and screening are then dealt with, both the process and the machines being described. The manufacture of superphosphate is then taken up, and of considerable interest in this connection is the description of the automatic superphosphate den. Weighing, elevating, dust extraction and other auxiliary processes in chemical manure manufacture are also covered. The book should be of value to any one concerned with crushing and mixing processes.

## ELECTRIC PROPULSION OF SHIPS.*

By W. E. THAU.

THIS paper will deal primarily with the electric propulsion of large ships, and as illustrative of large ship drives, a description and some discussion will be given of the propelling machinery of the United States Tennessee. In order, however, to make certain general comparisons helpful to the discussion, it will be necessary to introduce to some extent all feasible types of propelling equipment.

It is believed to be generally recognised by those who have made a broad study of the situation that the type of drive best suited to a given ship depends upon the characteristics of the ship, its trade route, and the cargo to be carried. These factors are so diversified that no unqualified preference can be held for any one type of propulsion, or in other words, there is a proper field for all principal types of ship drives.

The following types and arrangement of power drives have been applied with more or less success :—1. Direct-connected reciprocating engine ; 2. Direct-connected turbine ; 3. Geared turbine ; 4. Turbine electric with direct-connected motor ; 5. Turbine electric with geared motor ; 6. †Internal-combustion engine, direct-connected ; 7. †Internal-combustion engine, geared ; 8. †Internal-combustion engine- or Diesel-electric using direct-connected motors.

The principal objections to the reciprocating engine are those incident to its poor economy, and to some extent its weight and space factors. This type of drive, however, will exist for some time to come, as it has obtained a high state of development, and is at the present time better understood by the operating engineers. It is felt, however, that this condition will be greatly overcome as soon as the engineers now under training have become acquainted with the newer types of drive.

The development of the direct-connected turbine has probably gone as far as can be expected. This type of drive is being discarded because of its poor performance, as both the propeller and the turbine are operated at speeds not adapted to the best operating conditions of either.

There have been numerous applications of the geared turbine drive, and although there have been some disappointments, the general results indicate that the geared turbine drive has come to stay and enjoy a field of its own.

The turbine electric drive using direct-connected motors is a perfectly logical and applicable type of propulsion. Owing to the economy of high-speed turbines, alternating current is found best suited as alternating-current turbo-generators lend themselves very readily to high-speed operation. Two types of motors have been proposed and used, namely, the induction type and the synchronous type. The synchronous motor drive has slight weight and cost advantages over the ordinary induction motor drive, for the reason that the unity power factor of the synchronous motor permits a smaller generator, and the synchronous motor is cheaper to build than the induction motor. On the other hand, the induction motor drive has manœuvring advantages as it requires less skill in handling and possesses much better starting torque characteristics. The economy of the two types should be about the same.

Turbine electric drive using geared motors will probably see very little more development, as the speed reduction can be accomplished efficiently with direct connected motors without gears.

The internal-combustion engine, direct-connected to the propeller shaft, has been applied with considerable success in European countries, and is being given considerable serious attention at the present time in this country. From the fuel consumption standpoint, the direct-connected Diesel drive is far superior to any type of steam drive, and is certain to enter an era of prosperity. When compared with Diesel electric drive, however, the fuel economy advantages of the direct Diesel drive are small and other factors enter which show a gain for the Diesel electric over the direct-connected Diesel. At least, there is little choice from the fuel cost standpoint, as the additional weight of the direct-connected Diesel over the Diesel electric drive causes the net returns to be practically the same. As a matter of fact, the additional cargo that can be carried by a Diesel electric ship shows to a considerable advantage over short trips. The net fuel consumptions of the two drives are brought still closer for the reason that the direct-connected electric motor can be easily arranged for a lower and more efficient propeller speed than is usually the case with the direct-connected engine. There is a tendency to speed the direct-connected engines up in order to decrease weight per shaft horse-power, resulting in lower propeller efficiencies.

The ordinary internal-combustion engine using gears will probably see very little more development under present conditions. The internal-combustion engine or Diesel electric drive using direct-connected motors offers possibilities superior to those of any other type of drive, as will be shown in detail later.

For convenience, ship drives may be classified as follows, according to capacity of the propelling equipment : (1) Ships up to and including 6,000-h.p. ; and (2) Ships in excess of 6,000-h.p. For drives up to and including 6,000-h.p., we might logically have reciprocating engine, geared turbine, turbine electric, direct-connected Diesel, and Diesel electric types of propulsion.

For drives in excess of 6,000-h.p., we might have geared turbines and turbine electric. At the present writing, it is believed that the development of the Diesel engine in direct-connected units in excess of 3,000-h.p. is not perfected. Neither has the development of the high-speed Diesel units for electric drive been perfected in sizes which will permit a drive in excess of approximately 6,000-h.p.

Unquestionably, the prime consideration is reliability while economy, simplicity, cost weight and space are important but secondary considerations. One must not be unmindful of the fact that when a ship leaves port, it must absolutely rely on its propelling equipment to reach its destination, and, therefore, the lives of crew and passengers as well as the safe transport of the ship and its cargo are dependent upon the satisfactory performance of the propelling machinery. For this reason, reliability should not be sacrificed for any other consideration. Reliability necessitates close adherence to rugged and thoroughly proved apparatus which must, of necessity, stand more or less abuse without danger of failure. The machinery must operate continuously for days and possibly for months without shutting down, and must be simple within reason and thoroughly understood by the operators. Economy, cost, weight, space, &c., are important in that they determine the relative earning capacity of the ship.

### MERCHANT SHIPS.

With these general statements in mind, let us consider more closely the merits of electric drive first for merchant ships, and second, for battleships. As stated above, there are two general systems of electric propulsion, namely, that in which the prime mover is the steam turbine and that in which the prime mover is the Diesel engine. With the turbine electric drive, the electrical equipment is of the alternating-current type for the reason that alternating-current turbo-generators are inherently better suited for the high economical speeds of turbines. With the Diesel electric drive, the electrical equipment is of the direct-current type, because of its flexibility, ease of speed control and simple requirements of the engine governors. If alternating current were used with Diesel electric drive, the engine governors would have to be highly refined as it would be necessary to operate the generators in parallel ; whereas with direct current, the generators may be operated in series, thus permitting relatively simple engine governors. Even with parallel operation of the direct-current generators, the governor problem offers no serious difficulty, however, there are other decided advantages in favour of the series operation which will be discussed later. In the case of the turbine electric drive, the propeller speed is varied by throttling the turbine, and reversal of propellers is effected by reversing the motors connections. In the case of the Diesel electric drives, the propeller speed is varied any amount from zero to a

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* Read before a Joint Meeting of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, New York, January 28, 1921.

†Diese lengines or the equivalent.

maximum in either direction, without opening a single circuit, by merely adjusting the generator voltage by means of a simple field rheostat, the engines always operating at constant speed.

In the turbine electric drive, the motors are direct-connected to the propellers. As most ships up to 6,000-h.p. are of the single-screw type, there is usually but one turbo-generator and one motor. The electrical characteristics are usually 50 cycles to 60 cycles, 1,100 volts to 2,200 volts, and polyphase. The control of the apparatus is effected from a central control station usually located in the engine-room. The switches and turbine control valves are controlled by means of simple levers, symmetrically arranged and suitably interlocked in order to prevent improper operation. All necessary gauges and electrical instruments are mounted upon a panel directly in front of the operator, so that the performance of the machinery is under his observation at all times.

The turbine is equipped with a speed governor, over-speed stop governor and throttle valve. Where the throttle valve is not used to regulate the speed, some form of "power limit stop" is necessary to prevent excessive overloads being imposed on the machinery when manœuvring or by other causes.

In the case of twin-screw ships having two generating units, the turbine electric drive possesses the advantage of flexibility over direct-connected and geared drives, in that the failure of either generating unit will not seriously cripple the propelling equipment. Should one unit fail, the remaining unit would deliver equal power to both propellers to the extent of its full equivalent capacity, thus enabling the ship to make about 70 per cent. to 75 per cent. of full speed. This is also true to a large extent in the case of the geared turbine drive using cross compound turbines, as the failure of a high or low-pressure turbine element would mean the loss of only from 40 per cent. to 50 per cent. of the power. In the case, however, of complete expansion turbines, the failure of one unit would necessitate dragging that screw, resulting in a serious retarding effect. Large ships invariably have twin, triple or four screws, and therefore the flexibility of the electric drive is an important advantage.

For ships up to 6,000-h.p. (the larger sizes having twin screws) the Diesel electric type of propulsion possesses marked advantages over all other types. With this type of drive, any reasonable number of generating units may be used, independent of the arrangement of the propellers. It is, therefore, possible to use a number of relatively small reliable, high-speed Diesel engines driving direct-connected direct-current generators.* By using a number of the small units, the disadvantages of large Diesel engines are obviated. Aside from the reliability thus obtained, there is the added important advantage of flexibility with regard to reserve power, and as will be shown later, this advantage is possessed in an extreme degree only by the Diesel electric drive.

The electrical apparatus is well understood, thoroughly tried out, and there is consequently no question as to its reliability. The motors are separately excited at constant potential in one direction while the generators are supplied with excitation through a reversing field rheostat so that any desired voltage may be obtained from zero to the maximum in either direction. With this arrangement, the speed of the motors is directly proportional to the voltage of the generators. Therefore, the control is as simple as could possibly be desired.

Series connection of the generators with the motors interposed to reduce the ground voltage to a minimum has certain advantages over parallel connection of generators. For the purpose of discussion, let us assume a single-screw drive consisting of six generators and a motor consisting of two separate units mounted on the same shaft. (Fig. 1.) Electrically, the machines would be arranged in series as follows: Three generators, one motor unit, three generators, one motor unit. On the basis of 250-volt generators, the maximum ground voltage would be 750 volts, although from the standpoint of current, the system has all the advantages of a 1,500-volt circuit. This arrangement of generators and motors is independent of the number of either. Even with an uneven number of generators in series, the motor may be on different screws as in the case of a twin-screw drive, and still permit independent control of the port and starboard screws. However, with the same or opposite rotation of the screws, the amount of speed difference obtainable is somewhat limited, although wholly within requirements. In this case, the speed difference between the propellers is obtained by adjusting the motor fields. An even number of generators is preferable with twin-screw ships, however, as it affords more flexible and more positive control.

The advantages of the series system over the parallel system from an engine operating standpoint has already been covered. With the series arrangement, more power can be obtained from the remaining generator units in case of failure of one or more generator units, without providing excess capacity in the motors. The reason for this is that each of the remaining generators can be operated at normal voltage and the field of the motors weakened to increase the propeller speed to a value which will load the remaining generator units to their full capacity. With parallel operation, it would be necessary to lower the voltage of each generator a certain amount, thereby operating them at reduced capacity; or else to operate the remaining generators at full voltage and provide additional field capacity in the motors so that the speed could be lowered the required amount by increasing the motor field. Thus, in case of failure of a generator unit, parallel operation would either afford slightly less power than series operation or would necessitate slightly larger and heavier motors.

The Diesel electric system of ship propulsion possesses a flexibility of reserve power in the case of failure of prime movers which far surpasses any other type of drive. For example, assume a case in which there are three generators and one motor. Should one of the engines fail, the remaining two units could be operated at full capacity, giving two-thirds the total voltage and the motor speed increased by weakening its field to a point where the propeller would require two-thirds of full power, with a resulting ship speed of approximately 88 per cent. In the case of two engines failing, the available speed of the ship would be approximately 70 per cent. of full speed. And to assume the remote case of all main engines failing, the ship could make steerage way on the auxiliary generating sets. The multiplicity of units of the Diesel electric system affords another advantage of great importance, namely, that units can be overhauled at sea without entailing any serious loss of speed.

In the way of a summary, the following table of comparison of the various principal drives will be of interest. In arriving at the figures given, all items of machinery and supplies necessary to the main propelling machinery were considered; foundations, water, fuel, &c., were taken into account. However, it was necessary in some cases to make certain assumptions, but an effort was made to place such assumptions on the conservative side, so as not to show an exaggerated comparison. Further, certain major figures are at great variance in practice, and the table is, therefore, given as indicative of the trend of this comparison rather than actual proportions. The figures for turbine electric drive and geared turbine drive are based on the same steam conditions.

The figures are based on a 3,000-h.p. ship operating over a 4,000-mile course at a speed of 11 knots, and making a total of 14 single trips per year. The geared turbine ship is taken as unity. Owing to the present unsettled conditions, it is hardly possible to make an intelligent cost comparison.

| Drive. | Fuel Consumption. | Machinery Weight. |
|---|---|---|
| Geared turbine ... ... | 1·0 | 1·0 |
| Turbine electric ... | 1·06 | 1·05 to 1·10 |
| Direct-connected Diesel | 0·49 | 1·10 to 1·25 |
| Diesel electric† ... ... | 0·57 | 0·75 |

* It is not the intent of this paper to discuss Diesel engine, and it is assumed that it is generally recognized that Diesel engines having relatively small cylinders and operating at reasonably high speeds are thoroughly reliable and simple.

† There is a further decrease in fuel consumption with Diesel electric drive which has not been taken into account in this comparison, namely, that due to lower propeller speeds obtainable with low-speed motors.

*Fig. 1. DIESEL ELECTRIC DRIVE SCHEMATIC ARRANGEMENT ELECTRICAL CONNECTIONS.*

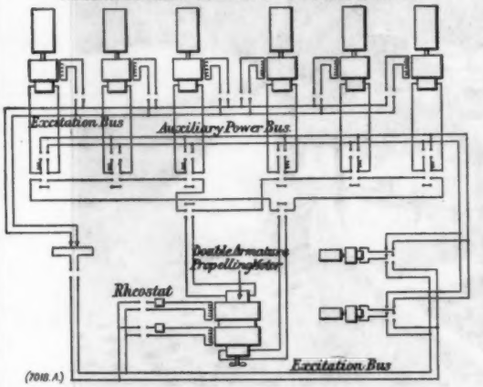
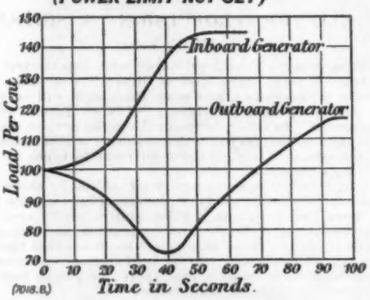



*Fig. 2. TURNING WITH 35-DEG. RUDDER (POWER LIMIT NOT SET)*




BATTLESHIPS.

The requirements of propelling machinery for battleships differ from those for merchant ships, principally in the degree of reliability and manœuvring ability. The reliability factor is of considerably greater importance, and must be made secondary to no other consideration. The manœuvring ability of a battleship is of great importance because of the range of speed at which it operates, and the promptness and accuracy with which it must respond to signals. Certain refinements are necessary for battleships which are not advisable for merchant ships, but because of the continually changing personnel of the former, these should always be kept within reasonable simplicity.

It is not the intent of this paper to compare various types of drives for battleships, and therefore only a few brief remarks will be made in this connection. The advantages of electric drive for battleships, or warships, lie particularly in the flexibility of the arrangement of the machinery with respect to its protection from torpedo attack. Secondary advantages lie in the availability of full backing power and flexibility of control. Flexibility of control is important, both from the standpoint of normal operation, and also emergency operation, as in case of a failure of one of the main prime movers. Within reason, the machinery can be placed where it is best protected from torpedo attack. The total floor area occupied by the propelling machinery and its weight might be slightly in excess of a well-designed geared turbine drive. However, if the geared turbine drive is arranged to be equally well protected from attack, it is possible that the slight advantages of these two factors would be of very minor consideration. Unfortunately, there are no comparable geared turbine drives in operation or under construction to enable a close comparison of these factors to be made. Similarly, there are no directly comparable ships having geared turbine propelling machinery to enable a comparison to be made of the economy. (In this connection, sister ships of the New Mexico having direct-connected main turbines and geared cruising turbines have shown decided poorer economy under all conditions than the New Mexico.)

*Fig. 3. PROPELLER TORQUE CHARACTERISTICS-REVERSING. SHIP GOING AHEAD AT CONSTANT SPEED.*

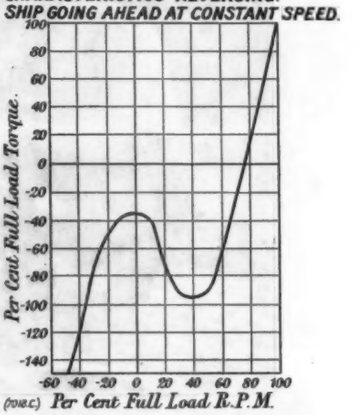
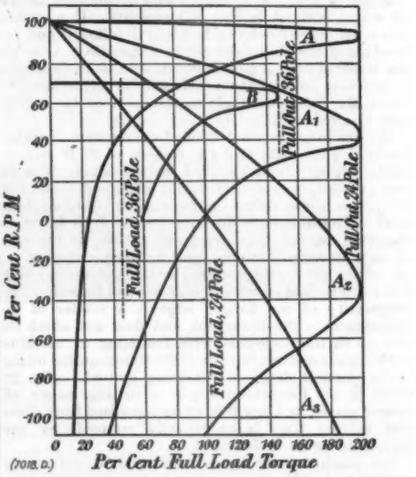



*Fig. 4. U.S.S. TENNESSEE MOTOR SPEED -TORQUE CHARACTERISTICS.*

*A-24-Pole (Wound Secondary)*
*$A_1$, $A_2$, $A_3$-24-Pole Winding with External Resistance*
*B-36-Pole (Squirrel-Cage Winding)*



It is safe to say, however, that the difference in economy, if any, would be very little. The geared turbine drive might show a slightly better economy at full power, whereas the electric would be expected to show better economy at the lower powers and cruising speeds, providing equal efforts are made toward economy by design and operation. In the case of the geared drive, it would be necessary to use all turbines (except where cruising turbines are provided) for any speed, whereas with the electric drive only a sufficient number of generators are operated to supply the power required for a given speed. This enables the generating equipments of the electric drive to be operated at full power nearly all the time. Furthermore, since the motors have two sets of windings, or the equivalent, the generators and turbines can be operated at higher average speeds over the entire range, resulting in better economy.

There can be no question as to the reliability of electrical apparatus as the propulsive power for ships of this class. Electrical machinery has been developed over a long period of years and has proven extremely reliable in all sizes, and the experience with this class of apparatus will support the statement that it is as reliable as any other class of machinery that can be installed on ships.

The experience of the engineer officers who have had charge of an electrically-driven battleship, and also of battleships having other types of machinery is that the electrically-driven ship is more easily controlled and affords quicker response to signals than any other type of drive. The equipment can be made in such a manner that the entire propelling equipment is under the control of one operator. In fact, such an arrangement will be used with the new battleships and battle cruisers. In this case, the control will be almost entirely electro-pneumatic, and the main operating board will resemble the control boards used in the large railway switch towers. Any desired rapidity of operation within reason can be obtained with the electrical equipment. For instance, upon receipt of a signal to go full speed astern from full speed ahead, the propellers can be made to turn over in the reverse direction inside of a period of approximately 10 seconds.

Also the facility with which electrical energy can be measured and indicated, enables the instantaneous conditions of the propulsive equipment to be observed at any time, and therefore enables the operating force to detect excessive shaft friction, damaged screws or other abnormal operation. The electrical instruments are also beneficial in operating the machinery at its maximum economy at all times.

Starting and running requirements under normal sea conditions are not severe. If, however, precautions are not taken to limit the power, it is possible to impose large overloads on the machinery when turning a ship or reversing. Fig. 2 shows the manner in which the power of the inboard and outboard sides varies when making 4 turn with 35 deg. rudder. The particular curve shown has been interpolated from the curve obtained on the battleship New Mexico when making 19 knots and turning with 35 deg. rudder. It will be noted that the power of the generator supplying the inboard side increases rapidly during the first 50 sec., at which point it reaches the maximum output of the turbine. On the other hand, the power delivered by the generator supplying the outboard side decreases rather rapidly during the first 40 sec., and then begins to increase rapidly until a constant value is reached at about 90 sec. An analysis of the curve shows that the inboard side developed an overload of approximately 45 per cent. when the maximum power of the turbine was reached. The outboard side dropped to about 75 per cent. of normal load at the end of the first 40 sec., and then increased to a value corresponding to approximately 15 per cent. overload at the end of 90 seconds. The total power at the end of 90 seconds corresponds to approximately 130 per cent load.

If such conditions as those mentioned above are not guarded against, it would be necessary to carry excessive excitation on the generators continuously as the equipment would have to be ready at all times to meet the requirement. This would result in considerably larger generators. However, to overcome this condition, a form of power-limit stop is provided, the function of which is to limit the amount of steam taken by the turbine to a predetermined value, which under normal operating conditions corresponds to an overload of about 10 per cent. The shape of the turning curves and the overloads obtained varies with the different ships, and it is, therefore, necessary to conduct a series of "drop out" tests on each ship in order to determine the field current that must be carried continuously at the different speeds to enable the ship to be manœuvred without liability of the motors and generators pulling apart.

Fig. 3 shows the conditions which exist when reversing a battleship at full speed. The relative proportions of this curve also depend upon the ship in question, but the curve shown can be considered more or less typical as showing the backing conditions. In order to show the motor torque available for taking care of the backing condition, a series of motor speed-torque curves have been plotted in Fig. 4. The motor in question is of the wound-rotor type, having adjustable external resistance. A few speed-torque curves have been drawn for different secondary resistance values, but with liquid rheostats, there would be an infinite number of such curves as the external resistance thus provided varies from a maximum to the short-circuited condition of the rotor. With this type of rheostat, it is possible to obtain the maximum torque at any instant. An inspection of the ship torque curve will show that the speed of the propellers drops to approximately 75 per cent. when the power is taken off. This portion of the curve is represented by the straight line to the right. At this point, the motor connections are reversed and the motors produce a torque opposing the turning effort produced by the motion of the ship on the propellers. This reverse motor torque then builds up to approximately full-load value at 40 per cent. ahead revolutions, and then decreased to approximately 35 per cent. when the propellers are brought to a standstill. When the speed of the propellers is increased from zero revolutions per minute to values as low as 40 per cent, full-load revolutions per minute, in the backing direction, the torque increases very rapidly, attaining at this point a value slightly in excess of 100 per cent. which is the maximum speed that can be obtained without exceeding full-load torque of the motor. This curve, however, is plotted on the basis of the ship maintaining its full lineal speed through the water. Under actual conditions, however, the ship will slow down considerably in the time taken to reach this point, and it will, therefore, be possible to obtain a higher rotational speed on the propellers in the backing direction than this curve indicates.

The most vital part of the curve is that at about 40 per cent. of full-load speed when bringing the propellers to a stop condition. In the case of wound-rotor motors, this condition presents no difficulty as it is possible to obtain torques considerably in excess of normal at any speed by simply adjusting the external resistance. In the case of squirrel-cage motors, however, it is necessary to introduce a special design so as to obtain a speed-torque curve which will enable the motor to deliver torque safely in excess of this requirement, and under the conditions of operation described.

Further details of backing and turning conditions can be obtained from articles by Commander S. M. Robinson, U.S.N., published in the Journal of the American Society of Naval Engineers, from which data for the above curves have been taken. All such conditions must, of course, be taken into strict account in designing and propelling equipment, and it is obvious that the turbines, generators, motors, and control must be designed as a unit in order that each will have characteristics which are sufficient to enable all parts of the equipment to function properly under the required conditions.

*Description of Apparatus.*—The propelling machinery of the United States S. Tennessee consists of four direct-connected, two-speed motors supplied with three-phase power through suitable control equipment at approximately 3,400 volts and 34·6 cycles (full speed) by two direct-driven, 2,075 r.p.m. turbo generators. The generators are excited from one of the 300-kw., direct-current auxiliary sets through a booster set, so designed as to vary the 240-volt bus voltage in either direction to a value best suited for the given condition. All engine-room auxiliaries necessary to the main propulsion such as the main and auxiliary condenser circulating and condensate pumps, the lubricating and governor oil pumps, the oil cooler circulating pump, and the main motor ventilating blowers are driven by direct-current motors supplied with power from the same generator which is used for supplying the excitation. One auxiliary generator in each engine-room is sufficient to supply the auxiliary load just mentioned.

From the maximum speed to a speed slightly in excess of 16 knots, two generators are used, and the motors are connected to the 24-pole winding; speeds below this are obtained with only one generator in use. Speeds up to and including 15 knots can be obtained with the motors connected to the 36-pole winding. The steam operating conditions are 280-lb. gauge at the boilers, 250-lb. gauge at the turbine throttle, and a vacuum of 28·5 in. of mercury referred to 30-in. barometer.

*Main Motors.*—The main propelling motors are of the induction type and are wound for two definite speeds at full frequency, there being a 24-pole and a 36-pole winding. The primary or stator has two independent windings, one for each set of poles. One set of slots accommodates both of these windings, there being two coil sides of each set of coils placed in the slot, one directly above the other.

The rotor has a three-phase, two-parallel star-connected winding, having balancer connections operating as such on the 24-pole winding. The 24-pole winding is connected to three slip rings. The balancer connections are connected to points of equal potential in such a manner as to form short-circuit paths for the rotor conductors when the stator is connected to the 36-pole winding, thus forming an ordinary squirrel-cage winding having straps connecting the rotor conductors together instead of resistance rings.

In general, the design of the motors follows standard land practise. There are, however, certain features, particularly in connection with the insulation of the windings that have been given special consideration to guard against the deleterious effect of salt and moisture conditions. The insulation is of the best-known material and is applied and treated in accordance with thoroughly tried methods. The coils are form-wound, and completely insulated before being placed in the slots. The insulation of the straight part of the coil which is imbedded in the slot consists principally of mica with just sufficient fibrous material to serve as a binder. The mica folium and mica plate constituting this insulation are applied loosely by hand, and the coil then placed in a special machine equipped with electrically heated bars which revolve under spring pressure, around the wrapper. This process softens the bond, and permits the wrapper to slide on itself, resulting in an extremely solid and compact insulation. After the ironing process is completed, the coils are placed in cold presses and pressed to the required dimensions. The ends of the coils where flexibility is required are insulated principally with specially-treated fibrous material. Wherever cotton tape or other material subject to deterioration at relatively low temperatures is used, it is for convenience of assembly only, and in no case are the insulating or mechanical qualities depended upon where there is a danger of the neighbouring iron or copper reaching a temperature questionable for class A insulation. The tape constituting the insulation for the ends of the coils is given several treatments of insulating varnish during the process of winding. This tape is joined to the insulation of the straight part of the coil with specially prepared cement. The outside coverings are thoroughly filled with insulating varnish by means of several successive treatments; each coating being baked on for a long period, resulting in an insulation having a coating which is impervious to moisture and capable of withstanding salt deposits and foreign particles of dirt, &c., which may eventually find their way into the motor.

The slots are lined with tough paraffined fish paper cells in order to protect the insulation of the coil from injury during the assembling operations. This cell laps over the top coil, forming a protection of the coil from injury by the micarta wedges which are driven in the teeth of the slots. The individually formed coils are separated from each other by micarta spacers and any additional space in the slot is filled with micarta plate, so that there will be no room for coil movement. The connectors joining the coil ends are insulated with thoroughly treated fibrous tape.

The bottom layer of stator coils is securely laced to a strong insulated steel supporting ring which, in turn, is supported to the frame by means of bolted brackets. Another insulated steel ring support is placed between the two windings of the stator and held in place by means of copper wires which extend around the ring and the individual coil ends of both stator windings. With this type of construction, all coil extensions are grouped into a single mass which is rigidly supported from the motor frame, thus preventing coil distortion from any cause whatsoever. The rotor coil extensions rest firmly upon a wide insulated support, to which they are secured by heavy insulated bands.

The mechanical construction of the motor is of the self-contained type in which the bearings are carried by suitable brackets which fit into recesses in the stator frame. The entire motor is supported by feet cast integral with the frame on either side. The bearing housings are readily adjustable radially by means of jack screws in the brackets, and after being adjusted are bolted rigidly to the bracket.

The ventilation is supplied by duplicate direct-current motor-driven exhaust blowers, each capable of 12,500 cub. ft. per minute maximum. In addition to these separate blowers, the rotor itself is provided with fan vanes which assist in the ventilation and which will supply sufficient air to enable the motors to be operated for brief periods at full load in case of failure of the separate blowers. The separate blowers are mounted on the top of the motors, and draw the air through the motor and discharge it through suitable ducts to the deck. The system of ventilation consists of the axial flow of air through the core and end windings, the air being drawn in through openings in the brackets and discharged through a radial duct at the middle of the core to an outlet at the top of the motor. Each motor is capable of delivering a maximum of 8,375-h.p. at a speed of about 185 r.p.m.

The stator is provided with six thermocouples which are used in connection with potentiometers mounted in the control room for measuring the hot-spot temperatures of the windings. This device gives actual measurement of the actual hot-spot temperature and readings taken therefrom need no further correction except the 5 deg. for insulation drop.

In order to maintain the temperature of the motors above that of the surrounding air when the motors are idle, direct-current heaters are provided. These heaters consist of a series of tube resistors secured to the motor frame and so arranged as not to cause any excessive local heating.

*Main Generators.*—The main generators are designed and constructed in accordance with standard land practice, except that the rotor is of the total enclosed type. The stator coils are insulated in substantially the same manner as described for the motor coils. Each generator is capable of delivering a maximum of about 15,000 kv-a. at approximately 36½ cycles. The air pressure for ventilation is supplied by means of blowers secured to each end of the rotor. The air is drawn from a duct below the generator through the end bells, entering the machine at each end of the rotor. From there, it is forced through the end windings, core, and air gap axially, and discharged radially through a central opening in the core and passes thence through a duct to the deck.

The rotor consists of a solid steel forging having radial slots for receiving the windings. The winding consists of a series of turns of bare copper strap, the insulation of which consists entirely of mica and asbestos. Similar to the motor, the generator is provided with thermocouples for measuring the hot-spot temperatures. These thermocouples also connect to the same potentiometer board in the control room. In order to prevent the generator from sweating when idle, steam heating coils are provided. These coils are so located as not to cause any excessive local heating, and all joints and connections to the pipe are made outside of the frame of the machine so as to avoid steam leaks into the machine.

*Turbines.*—The turbine is of the combined impulse and reaction type, allowing complete expansion of the steam in one cylinder. Steam from the throttle valve and governor valve is admitted to openings in the top

and bottom at the centre of the turbine through control valves in the connections to these openings, and thence into various nozzle groups. The steam expands in the nozzle and is passed through a set of impulse blades and thence through single-flow, high-pressure reaction blading; having passed through this high-pressure reaction blading, the steam divides, one-half continues through the low-pressure blading on the same end of the turbine, and the other half flows through an overhead connecting pipe to the low-pressure reaction blading on the other end of the turbine. An exhaust connection is provided at each end of the turbine. The number of hand nozzle control valves to be opened at one end depends upon the load and varies from one to three valves. The speed, of course, is regulated by the governor valve only, the use of the hand valves being merely to obtain the best economy and to prevent overloading of the boilers at the various standard speeds. The turbine is coupled to the generator by means of a pin-type flexible coupling.

The glands for preventing leakage along the rotor shaft are of the combined steam and water-sealed type. The water gland is designed to seal effectively at all speeds from and above half-speed. Below half-speed, the steam seal gland is used. The steam pressure is regulated by a reducing valve in the pipe line to the glands. The water for sealing is supplied by a small connection from the feed line. The water and steam for gland sealing is controlled by special automatic gland control valves.

Briefly, the principal speed-control system consists of a governor driven directly from the turbine shaft through suitable gearing. The governor, which is capable of holding a practically constant speed at any speed from about 25 per cent. to the maximum, is essentially a dead weight governor in which the dead weight is replaced by an hydraulic piston, resulting in a type of governor capable of functioning over a wide range of speed by varying the hydraulic pressure on the piston. The speed is adjusted hydraulically by means of a control valve in the main control room which regulates the oil pressure. A double-seated poppet valve located on the main steam inlet to the turbine is controlled through a floating lever oil pressure relay system from the main governor, and this valve controls the amount of steam required to maintain the speed for which the system is set. The governor control valve is also operated through a suitable oil pressure relay by a separate over-speed governor secured to the end of the turbine shaft. In addition, this over-speed governor also operates the main throttle valve in case of necessity.

In order to limit the power input to the turbine on overload conditions to an amount which will prevent excessive overloads on the machinery, and also prevent priming of the boilers, a power-limit stop is provided. This power-limit stop is arranged to limit the travel of the governor linkage in the direction which admits more steam, as mentioned above. The position of the stop is adjusted electrically from the main control room through a system of gearing operated by a small motor. In order that the operator may know the position of the power-limit stop at any instant, an electrical position indicating system is provided, the transmitter of which is driven by spur gearing from the power limit stop mechanism. The indicator is mounted on the main control board in the control room under the direct observation of the operator.

In operation, this system functions as follows: The speed of the ship is set from the control room for any given standard by means of the hydraulic speed-control system. The power-limit stop is then adjusted to limit the motor speed to a few revolutions above that corresponding to the standard speed. Should an overload occur from turning or from any other cause, the speed-control governor will tend to maintain a constant speed by admitting more steam. However, as the governor linkage has only an additional limit of travel corresponding to the few revolutions increase in motor speed, the steam which can be admitted to the turbine is limited, and consequently the overload has a fixed value for any given condition.

The power-limit stop may also be used for adjusting the speed of the turbine below any value for which the main speed governor system is set, and it accompanies this in a similar manner to throttling. Since the speed is a function of the oil pressure, oil gauges mounted in the control room give a further check on the proper functioning of the entire turbine control system. The over-speed stop may be operated direct from the over-speed governor, hand trip in the engine room, or by wire pull from the control room.

The turbine and generator bearings are lubricated by means of forced lubrication through a system of delivery and return pipes. Oil for the governor control system is also supplied from the same system. The oil is delivered to the governor system at 80-lb. pressure and to the bearings at 5-lb to 10-lb. pressure through a reducing valve or other suitable means. The oil pumps for circulating this oil are of the positive displacement rotary type. Two pumps are provided in each engine-room, one of which is motor-driven and the other turbine-driven, the turbine-driven pump standing by as a spare. Normally, the motor-driven pump is used. However, upon failure of the motor-driven pump from any cause, an arrangement of pistons operated by the oil pressure will automatically cause the turbine-driven pump to be placed in operation.

*Main Control.*—As in the case of any other drive, the control for the electric drive such as is installed on the Tennessee is operated under orders from the bridge. All controlling apparatus necessary for the operation of the main propelling machinery is located at a central place known as the control room and the operating levers are arranged so that the operator faces forward. All operations for the control of the ship are effected in this control room except the actual starting of the turbines. The circuit breakers for handling the main circuits of the propelling machinery are of the oil-break type, of sufficient capacity to open the circuits safely under full power and voltage conditions, although in normal operation the circuit breakers are never opened or closed while the circuits are alive, suitable interlocks being provided to guard against improper operation. All primary breakers are arranged in two rows athwart ship having an aisle between them through which the breakers may be inspected and removed, if necessary. Secondary short-circuiting breakers and the liquid rheostats for controlling the motor secondaries are located back of the operating aisle.

The circuit breakers are designed with special reference to ease of operating, having wedge-shaped contacts of the multiple finger type. The circuit breakers are operated in pairs from single-control levers. In order to kill any particular circuit completely, self-contained disconnecting devices have been provided on the reverser breakers, generator breakers and tie breakers. The breaker mechanism is so arranged that the breaker must be opened before it is possible to disengage the disconnecting device. This provision safeguards against danger to the men in case of improper or faulty operation. The inspection or repair of the circuit breaker or circuits of any one or two motors at a time is thus facilitated, and can be executed while the ship is under way.

The levers for operating the circuit breakers and the liquid rheostat valves are arranged in a single row directly aft of the circuit breaker structure. All instruments and gauges for indicating the performance of the machinery are located on control panels secured to the circuit breaker structure directly in front of the operators. The levers are arranged symmetrically so that those on the left of the central position operate the circuit breakers in the after generator and port motor circuits, while those on the right of the central position operate the circuit breakers which control the circuits of the forward generator and starboard motors. The connecting rods and bell cranks between the levers and the circuit breaker mechanism are located beneath the false floor which forms the operating platform.

The pedestals on which the turbine control valves mentioned above are located, and also the levers for operating the generator field switches, are located in the centre of the lever group. Suitable mechanical interlocks of the crotch and rod types are provided so as to prevent improper operation of the switch levers. All interlocking is so arranged that the field must be off and the steam control reduced to a low value before any of the operating or set-up breakers can be operated. This interlocking also necessitates proper sequence of operation in either starting or stopping, the broad purpose of which is to safeguard the machinery.

The arrangement of the control is such that either side of the ship can be operated independently of the other side when two generators are in use. With the tie breakers closed and either generator in operation, the port and starboard propellers may be operated in the same or opposite directions as desired, but at the same speed.

All starting and manœuvring is done on the 24-pole winding. When the motors are connected on the 24-pole winding, the secondaries are controlled by means of liquid rheostats. There is one double rheostat for port motors and one for starboard motors. The rheostat consists essentially of a two-compartment tank, the lower compartment of which serves as a reservoir for the electrolyte and also as a container for the cooling coils, while the upper compartment contains the electrodes which are of the plate type. When it is desired to use a rheostat, the valve in the upper compartment operated from the control stand by means of a lever, is closed, thus allowing the liquid to rise in the upper compartment. (The liquid is being continually circulated through the upper compartment at a low level by means of motor-driven pumps.) The rate at which the liquid rises depends upon the setting of the regulating valve located in the delivery pipe of the pump. This valve can be adjusted to suit the desired operating condition. After the liquid rises to its maximum level, it overflows to the bottom compartment. After the maximum level has been reached, the motor secondary is completely short-circuited by means of an oil circuit breaker which is operated by a lever from the control stand. The electrolyte consists of a solution of ordinary sodium carbonate.

In order to transmit the power from the generators to the control-room circuit breakers, and from there to the motors, three-conductor lead-covered cables are used, each cable containing all three phases, there being a sufficient number of these cables in parallel to take care of the total power. The cable ends are provided with pot heads forming water-tight seals from which the respective conductors are brought out and connected to very substantial and well-insulated bus structures located over the switches in the control room, and at the motors and generators in the motor rooms and engine rooms respectively.

The excitation for the main generators and power for the auxiliaries necessary to the propelling equipment is supplied from one of the 300-kw. sets in each engine room, as stated above. Connections of these circuits to the 300-kw. sets are made ahead of the carbon circuit breakers in order that an interruption by means of the circuit breakers will not shut power off the exciting circuits or the auxiliaries. The engine-room auxiliaries and the motor ventilating blowers are provided with ordinary starting devices having individual circuit breaker protection.

## CATALOGUES.

*Electrical Starting Gear.*—The City Electrical Company, Limited, 1, Emerald-street, Holborn, London, W.C.1, send us a catalogue of electric motor starters including inching and speed-regulating types.

*Steam Separator.*—An interceptor for freeing exhaust steam from oil, water, or other impurities is described in a catalogue received from the North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne.

*Marine Feed Water Heaters.*—The Griscom-Russel Company, 90, West-street, New York, send us a new edition of their catalogue of marine feed water heaters showing the essential details of construction and containing tables of dimensions and capacity.

*Gear Cutting Machines.*—A catalogue, including several illustrations of the Sunderland gear-planing machine and its work, with many letters from leading engineering firms, testifying to its accuracy and high productive power, comes from the makers, Messrs. J. Parkinson and Son, Shipley.

*Cranes.*—The Industrial Works Company, of Bay City, Michigan, U.S.A., send us a copy of their general catalogue of cranes—a very handsome volume of 96 pages. The cranes dealt with include various portable types for railway, dock and building work, and also some powerful locomotive cranes for railway breakdown work.

*Small Oil Engines.*—Messrs. Petters, Limited, Yeovil, send a new catalogue of their oil engines up to 8 b.h.p., referring mainly to complete sets for electric current generation, pumping, air compressing, hoisting, marine purposes and many kinds of farm and outdoor work. Both fixed and portable types are made and in all cases the complete set is on one baseplate or truck.

*Submersible Electric Pumps.*—We have received a catalogue of electrically-driven pumps for use under water in salvage, mining, irrigation and similar work from Mr. T. L. Reed Cooper, 11, Tothill-street, London, S.W.1. These pumps are also suitable for chemical works and other places where corrosive or inflammable gases are present. Their construction was illustrated and described on page 274 of ENGINEERING, vol. CX.

*Coal Treatment.*—The progress made in washing, crushing and storing coal is indicated in a special catalogue of machinery, &c., for these purposes, issued by Messrs. Simon-Carves, Limited, 20, Mount-street, Manchester, who have supplied numerous plants for use at home and abroad. Slack is washed to separate the coal particles from the earthy and stony matter at the rate of 40 tons to 150 tons per hour, and the processes employed are suitable for both ordinary commercial coal and coke-oven material.

*Deck Machinery.*—A new catalogue of ship deck machinery, including cargo winches, windlasses and capstans, driven either electrically or by steam, comes from Messrs. John H. Wilson and Co., Limited, Birkenhead. A sufficiently wide range of powers for cargo and passenger ships is made in standard sizes, and some illustrations of very powerful warping capstans for large ships are included. One illustration shows a windlass giving a direct pull on the warping ends of 35 tons at 60 ft. per minute, combined with a capstan giving a pull of 15 tons at 300 ft. per minute.

*Concrete Pipes.*—The Stanton Ironworks Company, Limited, Nottingham, are producing pipes made of reinforced concrete in five classes suitable for working pressures of 10 lb. per square inch to 100 lb. per square inch. Each class is made with internal diameters ranging from 4 in. to 60 in. It is stated that under excessive pressure these pipes are not liable to burst, as they are capable of expanding and allowing the excess pressure to escape by percolation, becoming tight again when the pressure is reduced. The necessary joints and branches are also supplied, and the catalogue describes the process of manufacture and methods of fitting.

*Colliery Dusting Machine.*—A catalogue containing an illustrated description of a machine for reducing the proportion of coal dust in the air in mine workings comes from Messrs. Oldham and Son, Limited, Denton, Manchester. The machine blows a cloud of dry stone dust into the air of the working gallery and the effect of this is that the explosive particles adhere to the stone particles and are carried down. The stone used is preferably shale. The machine is drawn by a pony, or otherwise propelled at a speed of 1¼ miles per hour, and the blowing apparatus is operated from the truck axles. Where explosive material formed 55 per cent. to 62 per cent. of the floating dust two trips of the machine reduced the proportion to under 50 per cent.; and five trips reduced it to under 34 per cent.

*Steam Turbines for Paper Mills.*—The coal consumed in a mill making paper from esparto grass was found to average 2·6 tons per ton of paper produced with reciprocating engines, but this figure has been reduced to 1·6 tons by introducing the latest type of steam turbine. The steam is used partly for driving power and partly for heating, and the economy results from generating high pressure superheated steam only and drawing the heating steam from the turbines at the low pressures required. The system is very clearly explained in a special catalogue issued by Messrs. C. A. Parsons and Co., Limited, Newcastle-on-Tyne, in which several illustrations of special plant are shown. In each case the design is made to suit the whole requirements of the mill, provision being made for using the surplus low-pressure steam. The catalogue deals specially with paper mills, but it serves to emphasise the necessity in all cases for designing the power plant to suit all the conditions of fuel and water supply in providing power, heat, &c.

# "ENGINEERING" ILLUSTRATED PATENT RECORD.

## SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

*The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.*

*Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.*

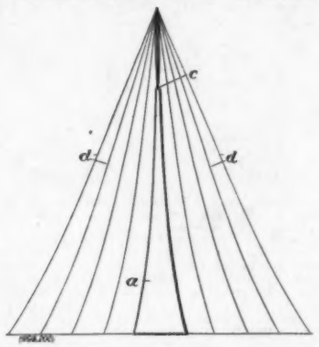
*Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of* 1s.

*The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.*

*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.*

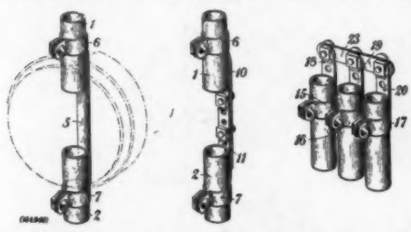
### ELECTRICAL APPARATUS.

**164,100. S. Mochl, London. Masts for Wireless Telegraphy.** (1 *Fig.*) February 27, 1920.—An aerial mast for wireless telegraphy comprises a self-supporting tower *a* of great




height, connected at or near the top by a universal joint to a slender column *e* which is anchored as shown by means of stays *d* attached to the ground. (*Accepted June* 15, 1921.)

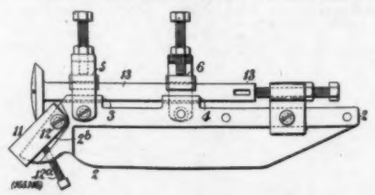
**164,946. A. E. Ryeland, London, and C. Ferguson, London. Bonding Metallic Tubing.** (3 *Figs.*) May 12, 1920.—To give the required continuity to allow the metallic tubing used in electrical wiring installations to be earthed satisfactorily, bonding means are employed and, according to this invention, comprise a strip of metal 5 having clips 6, 7, one




at each end, to be secured to adjacent sections of the tubing 1, 2. The metal strip may be unitary as shown in the left-hand figure, or formed in two parts 10, 11, secured together as shown in the central figure. For bonding three or more tubes, the clips 15, 16, 17 are each integral with a strip 18, 19 or 20, as shown in the right-hand figure. The strips 18, 19, 20 are connected with a common bridge member 23. (*Accepted June* 29, 1921.)

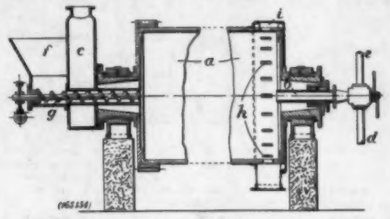
### GAS ENGINES, PRODUCERS, HOLDERS, &c.

**165,146. E. Cottrill, Hurst, Ashton-under-Lyne, and R. Rhodes, Werneth, Oldham. Internal-Combustion Engines.** (4 *Figs.*) February 20, 1920.—In apparatus, according to this invention, for removing deposit, pitting or scoring from, and trueing the faces of, the valves of internal-combustion engines, the tool 11 is pivoted at or towards one end and is adjustable about the pivot 12 by means of a screw 12a, which also serves as



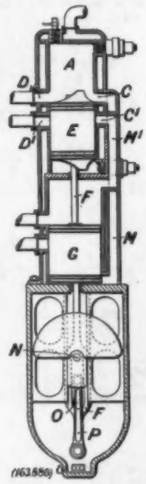

an abutment for taking the thrust in use. The tool 11 and screw 12a are mounted in or on an inclined extension or lug 2b provided at one end of the frame or holder 2. In operation, the stem of the valve 13 is mounted in the bearings 3, 5, and 4, 6, and the tool 11 adjusted to the inclination of the valve face. On the valve being rotated and having pressure applied to it axially, the face of the valve is rotated in contact with the tool 11 and is skimmed, scraped and trued up. (*Accepted July* 6, 1921.)

**165,154. The Underfeed Stoker Company, Limited, London, and S. McEwen, London. Carbonising Fuels.** (2 *Figs.*) March 13, 1920.—By the present invention low-temperature carbonisation is conducted in a grinding mill or pulveriser which is heated internally by the combustion of gas within the mill, the proportion of air used for the combustion being such that there is no appreciable proportion of oxygen in the products of combustion. A suitable mill is a tube mill *a* which is provided with a gas burner *b* extending through its trunnion at one end and a gas-offtake *c* communicating with its hollow trunnion at the other end. Gas, which may advantageously be some of that produced by the carbonisation, is fed to the



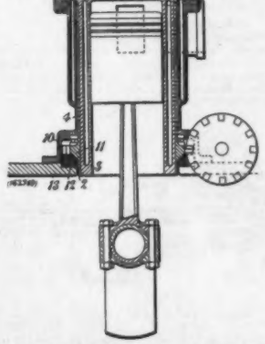

burner *b* through pipe *d* and air through pipe *e*. The fuel is fed from hopper *f* by a worm conveyor *g* into the opposite end of the mill. The carbonised material is discharged through the slots *h* into the substantially airtight stationary ring *i*. (*Accepted July* 6, 1921.)

**163,880. E. P. Lewns, London. Internal-Combustion Engines.** (1 *Fig.*) April 10, 1920.—In an internal-combustion engine of the type in which a compressor piston G is mounted on the rod of the working piston E and compresses air for use in the working cylinder, the working cylinder A is double-acting and has separate admission and exhaust ports C, C1, D, D1 for




each end of the cylinder. Passages M, M1 place the compressor cylinder in communication with the admission ports C, C1, respectively. The piston rod F is slotted at O and extends beyond the crankshaft, a pair of return connecting rods P, one on each side of the piston rod, transmitting the motion of the piston rod to the crankshaft N. (*Sealed.*)

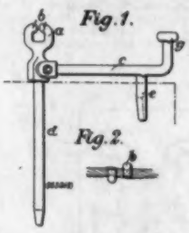
**163,749. T. W. Paterson, Liverpool. Sleeve-Valve Mechanism.** (1 *Fig.*) January 23, 1920.—In a four-stroke engine having a rotary sleeve valve between stationary outer and inner cylinders 4, 3, the inner cylinder 3 is spigotted into the outer cylinder 4 at the head and spaced therefrom at the foot by a coned ring 12, which bears against a coned surface 11 on the valve, means being provided for taking up wear. The drawing shows a sleeve valve 2 arranged between the outer cylinder 4 and the inner cylinder 3. The inner cylinder 3 is formed integral with the cylinder cap 5 so that they may be removed as a whole,




and the inner cylinder is spigotted into the outer cylinder so that the inner and outer cylinders are perfectly concentric. The sleeve valve is held against upward longitudinal movement by the ball race 10, and its lower part is provided with a coned shoulder 11 which engages within a complementarily-shaped bearing ring 12 fitted in the top of the crank casing 13 and the lower part of the outer cylinder. The upward reaction set up on the shoulder 11 from the bearing ring 12, when any side thrust is thrown against the sleeve valve, is by this means met by the ball races, and in this way the sleeve valve is rigidly supported against any sidewise movement tending to set up knocking. (*Sealed.*)

### LIFTING AND HAULING APPLIANCES.

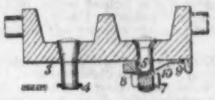
**163,912. Bell Brothers, Limited, Middlesbrough, and M. R. Kirby, Durham. Haulage Clips.** (4 *Figs.*) May 19, 1920.—In a haulage clip, to provide a simple and efficient means for coupling tubs, wagons and skips to a haulage rope, a fork *a* to receive the rope is carried by a rod *d* pivoted on a tub and having a hinged arm *c* provided with a locking stop *e*, the rod *d*




and stop *e* engaging opposite sides of the end of the tub when the fork is turned into its operative position to kink the rope. A projection *g* on the arm *c* engages an inclined way which knocks up the arm, releasing the stop *e* and allowing the fork to turn to release the rope. The ends of the fork are turned over in opposite directions. (*Sealed.*)

### MINING, METALLURGY AND METAL WORKING.

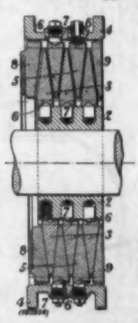
**164,137. J. Twaddle, Glasgow. Ingot Moulds.** (1 *Fig.*) March 4, 1920.—In some constructions of ingot moulds, the removal of the ingot is facilitated by the use of a plug projecting through the bottom of the mould and having a conical head terminating in a cylindrical shank equal in diameter to the minimum diameter of the head. To prevent the plug 3 or 5




falling out of the mould, its shank has, according to this invention, a projection 4 or nut 7 thereon. The plug may be wedged firmly in position by means of a wedge 8 inserted between the mould and the projection or nut. The wedge 8 is slotted at 9 to receive the plug 5, and has an inclined face 10, so that when the wedge 8 is displaced the plug 5 can be driven into the mould. (*Sealed.*)

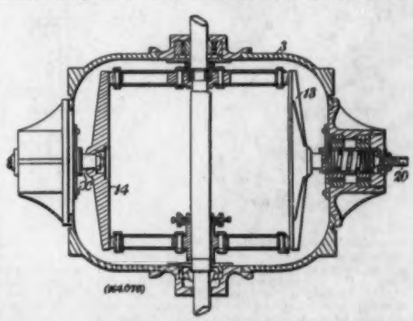
### MOTOR ROAD VEHICLES.

**163,804. T. Cooper, King's Lynn. Friction Clutches.** (1 *Fig.*) February 25, 1920.—In plate clutches the driving discs 3 and driven discs 5 are kept out of rubbing contact when the clutch is disengaged, as shown in the upper half of the figure,




by spring-pressed plungers 7, mounted in the boss 12 and casing 4, and engaging and acting on inclined surfaces or grooves 6 on the periphery or bore of the two sets of discs. The presser plate 8, back plate 9 and discs 3, 5, are tapered, the grooves being formed in the wider edges of the discs. (*Sealed.*)

**164,078. H. Edmunds, Brighton, and A. M. Banister, F. A. Grimes, P. J. McCarty, and R. D. H. Thompson, Brighton, and The B. M. R. Company, Limited, Brighton. Transmission Gear.** (7 *Figs.*) January 31, 1920.—In gearing of the kind in which co-axial driving and driven shafts each carry friction discs, one of which is slidable on its shaft, while two

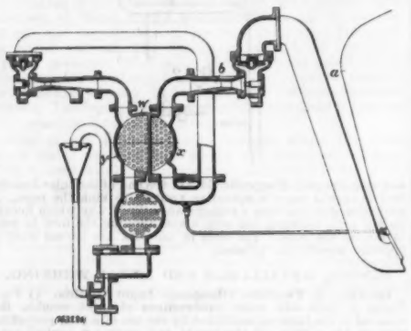



opposed transmitting discs are arranged at right angles to the driving and driven discs, the transmitting discs are operated by helical springs arranged in hubs, or hubbike extensions of the discs, by screws, which act on the discs directly or adjust the spring abutment. In the construction illustrated, the transmitting discs 13, 14 are forced into engagement by helical springs

contained in extensions, which turn in ball bearings in a gear frame or casing 3. The adjustable spring abutment is formed by a screw 20 acting through a thrust bearing. The disc is withdrawn by a lever acting on the shoulder *x*. (*Accepted June 15, 1921.*)

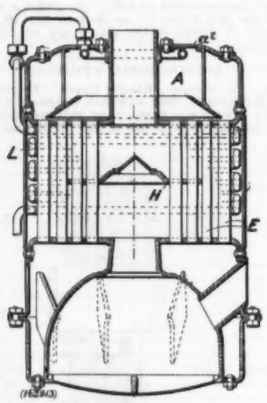
## STEAM ENGINES, BOILERS, EVAPORATORS, &c.

**163,224. G. and J. Weir, Limited, Cathcart, Glasgow, and C. R. Lang, Cathcart, Glasgow. Condensers.** (2 *Figs.*) June 23, 1920.—In apparatus for condensing steam and heating feed water comprising a main condenser *a*, a steam jet air ejector *b* for withdrawing the air from the condenser *a* and a combination



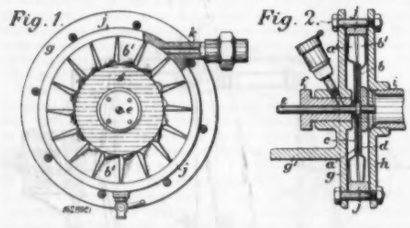
surface feed heater and condenser *w*, which are combined with a two-stage ejector having a condenser between the stages, the interstage condenser *x* is formed in the feed-heater portion *w* of the combination surface feed heater and condenser by a partition which divides the steam space into two chambers *x*, *y*. (*Sealed.*)

**162,913. Galloways, Limited, Manchester, and R. J. Smith, Urmston. Water-Tube Boilers.** (2 *Figs.*) May 1, 1920.—In a water-tube boiler having a lower water drum containing the furnace, an upper steam and water drum A, and water tubes E connecting the drums and passing through an intermediately-arranged combustion chamber, a superheater L



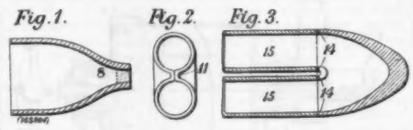
is placed between the outer row of water tubes E and the boiler casing. The superheater is of a two-element gridiron type, the coils of each element being of semi-circular form. The baffle plate H has a dome-shaped central portion. The inner portion of the dome is made removable for cleaning purposes and of such diameter that it can be withdrawn through the central uptake in the upper drum. (*Sealed.*)

**162,892. E. J. Mercer, Flixton, and Royles, Limited, Manchester. Turbines.** (5 *Figs.*) March 27, 1920.—A turbine with tangential inlet and central exhaust, which with reversed flow may be used as a centrifugal pump, comprises two discs *a*, *b* carrying relatively-inclined blades *a*1, *b*1, which direct the steam in a zig-zag path from blade to blade towards the



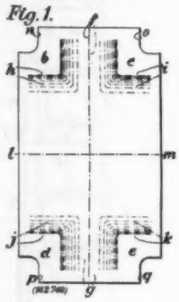
central exhaust. The discs *a*, *b* are clamped between two rigid plates *c*, *d*, fixedly connected to the spindle *e*. The two sides *g*, *h* of the rotor casing are spaced apart by means of a cylindrical body *j*, the inner circumference of which just clears the blades *a*1, *b*1. The width of the body part *j*, together with the necessary packing, is just sufficient to cause the side covers *g*, *h* to clear the sides of the blades *a*1, *b*1. (*Sealed.*)

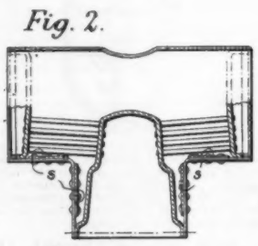
**163,864. Stewarts and Lloyds, Limited, Glasgow, and T. D. Watson, Coatbridge. Superheater Element Heads.** (7 *Figs.*) March 24, 1920.—In the manufacture of what are known as spear heads for connecting the tubes 15 of superheater elements, each spear head is formed from a single length of tubing by closing and shaping one end of the tube and forming a division 11 across the other. The operation is carried out in stages, the first consisting in reducing or pointing one end 8 of the tube, the second in closing and shaping the reduced end, the third in pressing or flattening the partially-completed head to a predetermined width, and the fourth in pressing



together opposite portions of the wall at the open end of the head so as to form the division. A fifth stage may be necessary to remove superfluous metal, whilst a sixth stage consists in chamfering, or recessing, the tubular ends 14 of the spear head in preparation for welding to the tubes 15. (*Sealed.*)

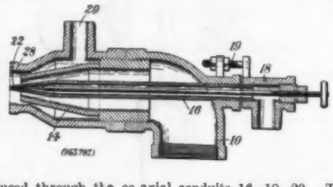
**162,749. Ruston and Hornsby, Limited, Lincoln, and J. Cunningham, Lincoln. Steam Generators.** (3 *Figs.*) January 30, 1920.—This patent refers to steam generators of the type in which a horizontal barrel is combined with a vertical end section surrounding the fire-box, and in which a tubular horizontal barrel is combined with a vertical fire-box shell disposed between the ends of the horizontal barrel and surrounding the inner fire-box, to constitute a steam generator shell of T-formation. The novel feature of this design consists in constituting the T-shaped generator shell of either one or two plates which, when in a heated condition, is or are pressed to the required form and connected together at the adjacent or abutting edges. The heated plate is placed between dies which act upon it at the corner portions *b*, *c*, *d*, and *e* and simultaneously shape each of the portions *f* and *g* to a semi-circular configuration





in cross-section, to form subsequently the fire-box shell, and also shape partly the portions at *h*, *i*, *j* and *k* to conform to the final shape of the lower part of the barrel. The edges of the plate thus pressed, are then trimmed, and the plate is reheated and pressed again to complete the cylindrical configuration of the barrel by pressure applied about a line parallel to the central line *l*-*m*. The trimmed edges of the portions at *j* and *k* then lie closely adjacent, or abut against, those of the portions at *h* and *i* respectively, and the trimmed edges at *n* and *o* of the portion *f* lie closely adjacent, or abut against, the edges *p* and *q* of the similarly-shaped portion *g*, to complete the vertical fire-box shell. The adjacent edges are then welded together and strengthened by riveting straps *s* over the seams. (*Sealed.*)

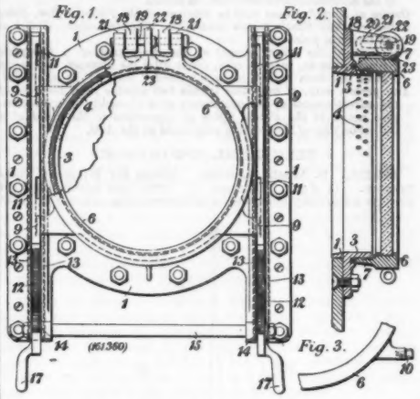
**163,782. J. B. Catterall, London. Liquid-Fuel Burners.** (1 *Fig.*) February 23, 1920.—In order to ensure complete combustion of heavy fuels, a combustible gas, which may be vaporised liquid fuel, is delivered to the burner co-axially with the oil and air, the air supply nozzle being set back from the open ends of the other nozzles. Means are provided to permit of the combustion of either or both fuels. Liquid fuel, air and gas are, respectively,



introduced through the co-axial conduits 16, 10, 29. The air supply nozzle 14 is set back from the other nozzles 22, 28. The conduit 16 may be adjusted longitudinally of its axis by the movement of the screw 19 and the connecting-piece 18. Gas may be used for starting up the furnace, or other apparatus to be heated by the burner, and the supply subsequently shut off or reduced. (*Sealed.*)

## SHIPS AND NAUTICAL APPLIANCES.

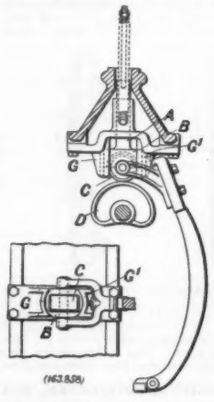
**161,360. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-upon-Tyne, and S. W. Fuidge, Newcastle-upon-Tyne. Side Scuttles.** (5 *Figs.*) January 27, 1920.—In a side scuttle for passenger vessels of the type in which the glass holder is capable of a movement about a hinge, and also of a movement at right angles to the plane of the frame, there is provided, according to this invention, a frame 1 having an inwardly-projecting spigot 3, through which are formed ventilating holes 4 and the glass holder 6 has a sleeve 7 which surrounds the spigot 3. At four points of the glass-holder 6 are projections 9, which are fitted with rollers 10. These rollers engage in cam slots 11 cut in racks 12 working in guides 13 on either side of the frame 1. Pinions 14, meshing with the racks 12, are fitted to a spindle 15. Handles 17 are provided on the pinions for operating them. Hinge brackets 18 are cast with the frame 1, the hinge pin 19 engaging in slots 20 cut in the hinge lugs 21 of the glass-holder 6. To assist alignment, a roller 22 is fitted to



the hinge spindle 19, and bears on a prepared face 23 on the glass-holder 6. To open the scuttle, the handles 17 of the pinions 14 are partly revolved upwards, causing the racks 12 to move downwards in their guides 13. The cam slots 11, being integral with the racks, also move downwards. The projections 9, or rollers 10, engaging with the cam slots move the glass-holder in a direction to uncover the ventilating holes 4 in the spigot 3 of the frame 1. On further movement of the handles 17, the racks 12 continue to move downwards and the projections 9, or rollers 10, come clear of the cam slots 11, allowing the glass-holder to be turned upward about its hinge. (*Sealed.*)

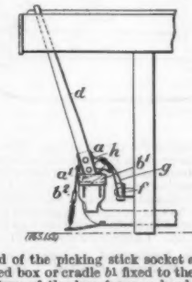
## TEXTILE MACHINERY.

**163,858. Sir Ernest Jardine, Nottingham, and E. Watchorn, West Bridgford. Twist-Lace Machines.** (3 *Figs.*) March 20, 1920.—To reduce the wear on the moving parts which is set up by the action of the point bar dipping cams D, each cam plunger A is provided with a casing B in which the anti-



friction roller C is mounted, and the exterior bearing surfaces of the plunger casing are cylindrical and concentric with the plunger A. These surfaces work in conjunction with similarly-shaped surfaces of dependent guide brackets G, G1. (*Accepted June 8, 1921.*)

**165,155. T. A. Montgomery, Armagh, P. Byrne, Gillis, Armagh, and R. J. MacDonald, Gillis, Armagh. Picking Mechanism.** (4 *Figs.*) March 15, 1920.—The object of this invention is to provide a simple and reliable construction of picking mechanism which is easy to start, gives a uniform pick and requires little power to complete each pick. The shoe or rocker *a*1



on the lower end of the picking stick socket *a*, is accommodated in an open-topped box or cradle *b*1 fixed to the rocking rail of the loom. The bottom of the box forms a level bearing surface *b*2 on which the curved bottom *a*1 of the socket *a* rests. The picking stick *d* is operated by the picking stick lever *f*, through the usual strap *g* and quadrant *h*, against the action of a spring. (*Accepted July 6, 1921.*)